

A Critical Examination of
New Constructional Techniques and
their Influence on Productivity in the
Building Industry with Special Reference
to Housing in South-East Scotland

PART ONE VOLUME II

by

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*"For the structure that we raise
Time is with materials filled."*

"The Builders"—LONGFELLOW

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PART ONE

(CONSTRUCTIONAL METHOD)

VOLUME TWO - NEW TECHNIQUES, EXAMINED AND CRITICISED.

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NEW TECHNIQUES EXAMINED

(1) House Foundations

House foundations have differed very little for many years, the normal strip concrete footings have been used in most cases except where the ground is made up or liable to mining subsidence, and specially designed foundations are required. Quite recently a new method of foundation construction has been tried out for one and two-storey houses and certain light school buildings⁽³⁴⁾. The method involves the use of short bored piles, cast "in situ", varying in depth up to ten foot and distributed at sufficient intervals along the line of the walls. The holes for the piles are bored by hand or mechanical auger, filled with concrete to a level about nine inches or so below normal ground level and then a horizontal concrete beam is cast over the heads of the piles. Alternatively the beam may be precast and possibly pre-stressed; in any case the beam is properly designed to safely support the particular wall loading.

This method of the short bored pile was primarily intended for the foundation in shrinkable clay, the piles penetrating to a depth beyond the effect of seasonal variations/

variations of ground moisture or the shrinkage due to tree roots. There is little clay in Scotland however and consequently there are few occasions when ten foot piles are necessary to counteract the effect of clay shrinkage. Even so, I consider that this technique of the short bored pile might often be advantageously used on foundations in Scotland where undulating ground is encountered or where, for one reason or another, the traditional strip foundation goes to a depth exceeding five or six feet. For example, a fairly extensive "no fines" housing scheme at Musselburgh ran into considerable trouble and expense owing to the presence of soft wet sand to an unexpected depth, and the cost of the necessary excavation and underbuilding proved to be very considerable indeed, for while the contractor had won his contract on a very tight margin indeed, he had included a comparatively high rate for the underbuilding on a measurement basis! This was, of course, yet another example of unnecessary expense to the ratepayer owing to the lack of pre-planning and site investigation.

The short piled foundation must be designed to suit the individual site. Excessive settlement and differential settlement must be guarded against and the beam/

beam linking the piles must be carefully designed also. Again, the beam will be situated only a short distance below ground level, otherwise there is no saving of excavation; consequently there must be some form of seal or closure between the wall beam and the ground floor sub-base to prevent the entry of rodents and other vermin under the wall beam.

The mechanical excavation of foundation trenches can often effect considerable economies in house-building. The machines which are most suited to this work are the ordinary excavator used as a "back acter" and the multi-bucket type of machine which excavates by a continuous rotary process. But it is essential for the success of this means of excavation that there should be sufficient work on one site to justify the initial expense of placing the machine on the site. Research has shown that for the excavation of house footings on any site of less than twenty pairs of houses, mechanical excavation is not likely to be profitable.⁽³⁹⁾

Compared with the short pile method, mechanical excavation is at a disadvantage because the trench, when excavated, must be filled with concrete or brickwork. On the other/ hand the/

the piled foundation depends so much on the bearing capacity of a comparatively small area of ground which cannot be closely examined other than by inspection of the material excavated from the borehole.

Substantial savings in the cost of foundations can be realised by the careful planning of loadbearing and non-loadbearing walling and other elements of the structure so that each part of foundation bears some relationship to the load which it has to carry. If the floor joists and other members subject to loading are designed to distribute their loads on the crosswalls only, then front and rear elevations can be designed as light panel walls resting on a correspondingly light and shallow foundation. How many times does one see a large window or door opening in a wall, and below it, a deep and expensive concrete foundation carried through from corner to corner?

The traditional Scottish method of forming a scarcement at the base of walls for joists to rest upon is rather wasteful of materials and expense. If the English method of completely separate sleeper walling is not to be followed, surely a $4\frac{1}{2}$ inch corbel would meet the case and cut out a lot of needless brickwork and concrete which, it must be remembered, goes all the way round the building, unbroken by doorways or window openings.

The high cost of manual labour since pre-war years and the comparatively lower level of production has given every encouragement to the development of mechanical excavating plant in foundation work. The machines commonly used in the excavation of footings are rotational multi-bucket trenchers, single-bucket excavators attached to ordinary tractors, small "back acter" diggers and earth augers for pile foundations. ⁽³⁹⁾ The single-bucket excavating equipment attached to an ordinary general purpose tractor is probably the most economical machine for the average sized contracting firm, though it may be worth while hiring a large multi-bucket trencher if the bulk excavation of the foundations to thirty or more houses is contemplated. For less than twenty houses it is debatable whether mechanical excavation is economically justified, for there are so many factors to be considered - the type of ground for example - where hard compact clay with imbedded stones might cause frequent delays and additional hard work clearing up the ragged sides of excavations made in such ground.

The plan form is another factor affecting mechanical excavation; simple cross wall construction is admirably suited to rapid mechanical excavation, for the front and rear/

rear walls rest on the oversite concrete and awkward trench "returns" are thus reduced. A multiplicity of short return walls in a complicated layout creates considerable difficulty for the mechanical excavator which is so often limited in its power to manoeuvre.

Mechanical excavation, to be successful, demands a high standard of site organisation, the excavating machinery must be fully employed from the moment it arrives on the job until it leaves it, and only careful planning of the sequence of foundation work will ensure this. It is good site organisation to have the drainage trenches excavated while the mechanical equipment is on the site, yet how often does one see the drainage work left until the building is roofed with the result that access to the interior of the building is hindered by a chaotic jumble of materials, open trenches and heaps of earth.

Setting out trenches for mechanical excavators demands a different technique to that used for trenches ~~that~~ ~~are~~ excavated by hand. Centre lines are marked out, together with guide lines for the machine. The route the machine has to follow must be carefully planned so that turning is reduced to a minimum; also the plan must provide against the machine being forced to cross trenches that have already been excavated./

excavated.

Accuracy of setting out is most important, for there is little economy in mechanical excavation if trenches have to be straightened up by hand or if concrete is to be wasted in filling up bulges in trenches. Even with accurate setting out a careless or incompetent excavator driver may go deeper than he should, or may take out wider trenches than are required for the particular footings. His mistakes may not add up to much on his own timesheet but the correction of these errors by hand excavation or extra concrete is an expensive business.

For an average sized contractor's organisation it is open to doubt whether the purchase of special excavating machinery is economically worth while. The Building Research Station's studies during recent years suggest that mechanical forms of excavation are economical for the foundations of twenty houses or more, but if, as is stated by the B.R.S., two men and a machine can excavate the trenches for a pair of houses in 12.9 hours, then at least 160 houses would be needed every year in regular sequence to keep the machine occupied. A tractor fitted with a single-bucket excavator is, I consider, a better proposition for the average sized contractor. Such a machine can be adapted to work as a bulldozer, /

bulldozer, auger, hoist, etc., and would have a greater prospect of being kept fully in use. Only if a contractor had a large housing contract providing continuous excavating work say for two years, would it be worth while hiring a special trencher.

The photographs show one of these adapted tractors in use on a housing site.



New Housing
Estate at
Roslin, Nr.
Edinburgh.

The machine is being used to excavate a drainage trench between five and six feet in depth, and when the drains have been laid and tested the same machine is used to bulldoze the excavated earth back into the trench.

The particular site shown in the photograph is on the outskirts of Edinburgh, approximately 100 houses were in course of erection and the convertible tractor was kept continuously in use on a wide range of excavating work.

Improved Methods of Placing Concrete in Foundations.

The normal method of placing concrete in house foundations and ground floor areas is by barrows working from powered mixers. Wide variations occur in the quantity of concrete placed per man hour according to the type of mixer and the efficiency of site organisation. For each mixer there is an ideal cycle of operations which can only be achieved by careful and knowledgeable planning in order that the mixer is in the right position, both for loading and discharging, also that the number of loaders and placers is just right and the mixer can discharge its contents promptly without waiting. It is this last requirement which is so difficult to satisfy because the conventionally sized wheelbarrow cannot take the entire discharge from even the smallest mixer drum, consequently there is a certain amount of idle time for the machine when it is turning over and waiting for barrowmen to return.

Several types of equipment have been developed to enable this prompt discharge of the mixer's contents and they vary from powered barrows to delivery booms and rails. The powered dumper has been used extensively but its use has been confined generally to earth moving on civil engineering/

engineering works.

The more recently developed machines are lower, more compact, and are better suited to the small scale building site; they can be controlled by an operative walking behind or the larger types may allow him to ride; they may be three-wheeled, four-wheeled or track-mounted. But these mechanical barrows have their disadvantages; they cannot always manoeuvre well among the interlaced foundation trenches, and where a light plank bridge may be sufficient for an ordinary wheelbarrow there must be something rather more substantial for the heavier powered barrow. Also the wheeled machines do not perform well over very soft ground and some form of track has to be laid down for them; on the other hand the tracked vehicles move well over practically all types of ground, rough or soft, and are suitable for light earth-moving operations such as trench filling and levelling. All types of mechanical barrows are, of course, useful for all kinds of load carrying in addition to concrete placing.

The Italians and other continental builders make wide use of a "pram" type of wheelbarrow for the transport of concrete. This wheelbarrow has two wheels and its capacity is considerably more than the normal British wheelbarrow; the two wheels are very large and this assists movement/

movement over rough or soft ground, particularly from a standing start. The photograph below presents a rather distant picture of one of these "pram" wheelbarrows being hoisted to an upper floor of a new building in Turin.



Conveyor booms, belts and rails have been the subject of experiment for some years and quite recently the Building Research Station has developed a latticed steel concreting boom, 40 ft. in length, weigh^{ing} 430 lbs. and capable of carrying a load of 15 cwt. at mid-span⁽⁴⁰⁾. The boom is operated in a horizontal position, one end

pivoted on or over the mixer and the other end supported in an "A" frame mounted on wheels so that the boom may be swung round through about 180 degrees, using the mixer as the centre of the arc. A bucket or skip runs along the lower rail of the boom, being suspended by hoisting gear attached to a trolley. The contents of the bucket can thus be deposited at any point along the boom.

The use of such a conveyor boom eliminates plank/

plank walks and barrows, but it cannot operate on steeply inclined sites and it is of little use for other building operations. Moreover it must be carefully sited so as to include as much as possible of the building excavations within its operational arc, for a complete change in the boom's position will keep six men occupied for about $\frac{3}{4}$ hr.

The mono-rail transporter has been successfully used for transporting concrete from mixer to foundations or floors. A self-propelling tipping wagon operates along a single rail track and can be made to stop automatically at any point along the rail by fitting a trip device to the rail. No driver is needed and the wagon simply shuttles backwards and forwards between the mixer and the particular delivery point. The only advantages the mono-rail appears to have over the conveyor boom are that the wagon travels without a driver while the conveyor boom skip has to be pushed, and the length of mono-rail can extend for several blocks of houses while the conveyor boom can extend a distance of 40 feet only. On the other hand, ^{the} mono-rail may have to be set up in three different positions in order to reach all foundation trenches.

In 1954 the Building Research Station published ⁽⁴⁰⁾ a series of estimations by time study technique of the performance/

performance of mechanical barrows and transporter booms in the concreting of foundation trenches. In each series of observations a 10/7 concrete/^{mixer}was used and both three-wheeled and tracked types of mechanical barrows were compared against the transporter boom. The figures are as follows:-

Type of Equipment	Combined Plant and Labour Cost per cubic yd.	Hourly Running cost of plant.
Tracked mechanical barrow	6/3d.	6/11d.
Three-wheeled " "	5/4	2/6
Transporter boom	6/10	2/0

The B.R.S. publication did not give comparative data on the mono-rail transporter except to state that for one pair of houses the estimated performance should be 4.7 cubic yd. per hour against an approximate operating cost of 25/- per hour. This would give a cost per cube yard of roughly 5/3d.

It appears from these plant and labour cost totals that the transporter boom method is the most expensive and bearing in mind the all round usefulness of the mechanical barrows it does seem that where a contractor cannot afford both, then he would be best advised to choose/

choose the mechanical barrow. In my opinion the tracked barrow is the better proposition on account of its versatility and its ability to move with freedom over rough or soft ground.

Whatever method of placing is used, it is important that the skip or barrow should have at least a 7 cu. ft. capacity so that it can take the entire discharge from a 10/7 mixer. The use of ordinary wheelbarrows seriously delays the operation of the mixer and prevents it from running at an economical batch cycle time. A wheelbarrow has a concrete carrying capacity of about $1\frac{1}{4}$ cu. ft. and it will thus take six barrow loads to discharge the seven cu. ft. from a 10/7 mixer, and the inevitable delay in the timing of the mixer cycle can bring about a reduction of approximately 35% in the mixer's output.

This emphasises a fact that is not always appreciated fully by contractors using mechanical plant - machines can only save labour and cost when they are working. The programming and sequence of concreting work on a building site must be such that machines are kept fully in use and are never idling. It is a common experience on too many sites to see concreting equipment with drums rotating wastefully or not at all.

Domestic Drainage.

Apart from the pitch-fibre drainage system there has been no important change in underground drainage method since glazed ware pipes were first used in water-bourne sanitation. There have been attempts to reduce the cost of house drainage by various improvements in design and layout, but architects are so often obstructed in their efforts for economical house drainage by the uncompromising requirements of building by-laws.

The cost of underground house drainage is usually between 3% and 6% of the total cost of the house. On a house costing say, £1,200 there might be a difference of £36 i.e. 3% between the drainage cost for House A and that of House B. Of course, there may be unavoidable difficulties in the one layout where, for example, the site may undulate sharply or may slope the wrong way, while in the other layout the site might be perfectly level or even have a slope towards the sewer coinciding with the gradient of the drain. But on comparable sites it is very probable that there can still be a difference of 3% between a traditionally designed drain and one designed for economy with efficiency.

One means of economy that must be obvious to any layman who passes a building site, is the restriction of connections/

connections to the public sewer. Indeed it must appear most elementary to anyone who has driven a car or travelled in a 'bus past housing estates under construction, that there is an excessively high number of cuttings made in existing road surfaces, with all the inconvenience of road blockages, indifferently made-up trenches, etc., This kind of thing can be seen almost anywhere in Edinburgh, and when one reckons up the cost of a sewer connection in a main road, with all the attendant expenses of barriers, signs, lighting, watching, etc. not to mention the inconvenience to road users, then it is surely high time that the local authorities put a stop to this and compelled builders to connect to economically distanced sewer connections provided by the local authority.

The same kind of thing happens with water connections and the other services. Quite recently I replaced an existing spring water supply to two cottages by a connection to the Edinburgh water main in an adjoining road which took a considerable volume of traffic including a public 'bus service. In doing so I ventured to take into consideration the likely needs of adjacent cottages served by the same spring and made the size of the water pipe serving the two original cottages adequate in diameter to cater for additional connections if the need should arise. The initial cost of the connection was/

was in the region of £50 to £60 and so far, one additional privately owned house has tapped on to this connection and the owner paid £15 for the privilege of being allowed to do so. There may be others who will take advantage of this initial connection to the main supply, but if they elect to have their own private and direct supply to the corporation water mains pipe, who shall prevent them? One would imagine that the water authority would insist that all these odd connections were grouped within the one connection. But either the water regulations prevent the administering authority doing this, or it may be that the cause is simply due to a lack of foresight and planning. Whatever it is, there is little doubt that these duplicated connections in busy thoroughfares could be quite easily avoided, and quite substantial economies realised in consequence.

The provision of access to underground systems of drains has always been an expensive item in any drainage layout. The minimum size of manhole is 2 ft. by 1 ft.6 in. and the brickwork, concrete base and cover to quite a shallow manhole can add up to a substantial amount of money. The general view of the Building Research Station and a recently constituted National Committee on Domestic
(41)
Drainage has been that the provision of intermediate access to underground drainage systems has quite often, in the past, been overdone/

overdone. In the Report of the Plumbing Committee it was stated that " if drains are properly designed and constructed, stoppages, are rare, and manholes are called for only at certain critical points in the system" The Report went on to say that the Committee thought it " preferable to take the slender chance of a stoppage (digging out if necessary) rather than burden a scheme with manholes which may never be used and which in themselves may be the cause of the stoppages".

The Codes of Practice Committee have expressed the view that " means of access to drains and sewers should be reduced to the minimum necessary for each section to be separately tested, cleaned and rodded." ⁽⁴¹⁾ This seems to be a little at variance with the Plumbing Committee's insistence that only a few manholes are necessary in most drainage schemes, for if every section is to be reached by rods then surely this means that every single branch is to be provided with an access point of some sort.

From my own industrial experience of drainage stoppages the manhole is an infrequent cause of trouble; the chief cause is the joint which has been imperfectly cleaned on the inside of the drain, and cement mortar jointing material has been allowed to protrude into the bore of the drain. In domestic drain construction, particularly in the four/

four inch diameter size, it is remarkable how few drainers follow the recommendations of the latest Code of Practice with reference to the use of tarred gaskin in jointing and it is still more remarkable how few local authorities follow the Code's very sensible recommendation for tests for obstruction.

In the Edinburgh area most drainers use neat cement for jointing (this again is contrary to the Code's recommendations) and they rarely use tarred gaskin to prevent the cement from entering the bore of the drain and to centre each spigot properly within the collar of the preceding pipe. Instead they bed the pipes in cement and use a "half-moon scraper" to take out the excess cement, then the joint at the sides and top is filled by ramming cement into it. It is not possible to use the scraper to clean out any cement that is rammed right through into the drain bore, neither is it possible, without the protection of tarred gaskin, to be absolutely certain that some unavoidable disturbance to the drain before setting does not take place, causing the soft jointing material to be squeezed into the interior of the drain.

With this uncertainty and risk of obstructive material in new drains one would imagine that local authorities/

authorities would be more than anxious to apply the ball test recommended by the Code of Practice ⁽⁴²⁾ as essential to guard against these obstructions. Yet the Edinburgh City Drainage Department does not apply this test, nor is it used in Midlothian or anywhere in Scotland to my knowledge. At the same time, few authorities in England test for drain obstruction, though at Coventry the ball test has been used for at least twenty years on both drains and chimneys!

From what has been said it would seem that some considerable improvement in methods of drainlaying and drain testing is necessary before the number of points of access to drains can be materially reduced. Quite often however, the number of manholes can be cut down by introducing rodding eyes at carefully chosen points where the drain is shallow. The "handhole" incorporated in the lowest length of iron soil pipe is practically useless for really effective rodding of drain branches and I have always thought that this "handhole" should be supplemented by a rodding eye formed in the first length of fireclay drain as it leaves the cast iron soil pipe.

Rodding eyes can be quite easily constructed at the various points in a straight length of drain, particularly at the head of the drain. Manholes are most certainly needed wherever the drain changes direction, but where the depth is not excessive the size of the chamber should be reduced to a bare/

bare minimum in size and the brick wall should not be any thicker than $4\frac{1}{2}$ in. It is useless to try to prevent the entry of water into a manhole, for if the subsoil is saturated nothing short of asphalt will hold the water back. The same remarks apply to the concrete base to the manhole, its function is mainly to support the enclosing manhole walls and the drain itself, so there is hardly ever any necessity for six inches of concrete at the base of a manhole - yet how often is this thickness, and more, provided in situations where three or four inches thickness would be quite sufficient.

The minimum size recommended for a shallow manhole is 18 in. by 24 in. ⁽⁴²⁾ and this is quite large enough for access points up to a depth of about four feet. Where the depth of the manhole exceeds four feet the length of two feet must be extended accordingly so that there is room for drain rods to curve easily from their introduction vertically to horizontal entry into the drain. But this extension of length at the bottom of the manhole need not be continued throughout the entire depth of the chamber. Careful corbelling back from the base measurements of the manhole can reduce the size gradually so that the minimum of 18 in. by 24 in. can be achieved for the last three or four feet at the upper part of the manhole. This will provide adequate accessibility with a substantial saving in cost.

Further economy in the construction of manholes is possible when the concrete base is set out. More often than not the overall size of the manhole is increased by three or four inches all round the perimeter of it to form an offset similar to that between foundation concrete and ordinary house walling. Such an offset for a manhole wall is quite unnecessary for there is little weight to support and the containing soil provides adequate resistance against lateral wall movement. It follows then that the excavation and backfilling resulting from this unnecessary offset should be avoided by careful setting out - the saving may be slight when one manhole is considered but in a large housing scheme the saving would be substantial.

In the Plumbing Committee's Report on Domestic Drainage ⁽⁴⁴⁾ the criticism was made that pipe diameters were often too large for their purpose. This criticism is certainly well founded so far as Scottish drainage practice is concerned, for it rarely happens that more than two houses drain into a 4 in. diameter drain and any proposal to connect ten or twelve houses to such a drain would not be likely to find favour with the general run of Scottish local authorities. Even in the single house draining into a 4 in. diameter drain one finds the 5 in. diameter "tail" drain/

drain between the intercepting chamber and the sewer connection. This is quite unnecessary and probably puts an additional cost of £2 or so according to the length of the "tail drain".

The latest Code of Practice for Drainage states that several houses can be jointly drained into a four inch diameter pipe. It is unfortunate that the Code does not lay down the maximum number of connections that may safely be made to this diameter pipe, for "several" houses might be understood to mean three or four or perhaps a dozen. I have quite often used 4 in. pipes to drain up to twelve houses. Usually the drain layout has been planned so that two units of six two-storey houses have 4 in. pipes taking up all the branched connections at the rear of the houses and then leading into a 6 in. length of drain laid between the two units of six houses and connecting to the main sewer in the roadway at the front of the houses. This drainage work was carried out in England and has been quite satisfactory over a period of twenty years. The 6 in. diameter pipes in the last section of these drain layouts could, in Scotland, have been reduced to 5 in. diameter pipes, for this size of pipe is available in Scotland but is not manufactured by English firms.

When pipes are too large for their purpose they are not/

not only unnecessarily costly but they may also be less satisfactory in use than the smaller diameter pipe, for it is common knowledge that a half-bore flow together with the right velocity of flow will go farther to secure self-cleansing in the drain than the sluggish shallow flow in an over-large drain.

Special fitments in drainware are expensive; bends, branches and access pipes - they all range from 10/- to £2 or so each - and traps may be even more expensive. Yet it is usual in most drainage layouts in Scotland to be required to provide two underground traps at least - a two-piece Buchan trap in the intercepting chamber and a trap between surface water branches and the point where they link up with the foul-water drain. The age-old arguments for and against the provision or omission of an intercepting trap are too well known to be repeated here, but it surely does seem ridiculous to go on incurring the substantial cost of the intercepting trap between public sewer and private drain, not to mention the far greater cost involved in providing satisfactory fresh air inlets, when the surface water connections are already disconnected by an underground trap and all the sanitary fitments have traps below their waste outlets.

With all due respect to good intentions I consider that/

that building costs have for many years been forced up unnecessarily by drainage and sanitary authorities who have always believed that drain air carries with it fearful dangers of infectious diseases. These authorities have always placed too great an emphasis on the need, at whatever cost, for placing two, or more often three expensive obstacles in the way of drain air seeking to enter the house interior, and the Scottish local authorities are far more insistent about this matter of traps than any of the large English local authorities. Yet there is no single substantiated record of the inhalation of drain air ever having had a harmful effect on the health of a single human being. Admittedly the musty odour of drains is not pleasant and should not be tolerated in any circumstances, but one efficient trap between drain and fitment ought to be sufficient.

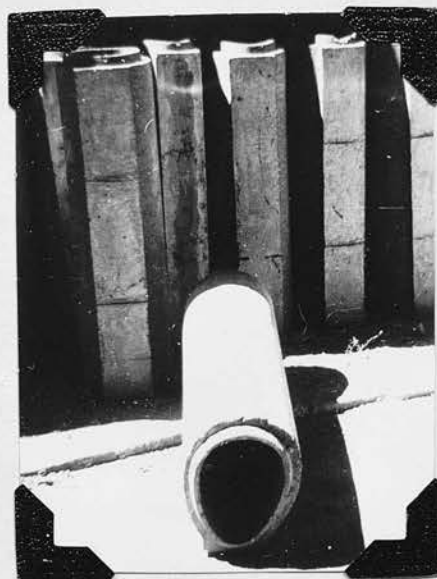
In the Report of the Plumbing Committee (already referred to) the opinion was expressed that "second trapping" is not necessary, given good design and workmanship in plumbing and drainage, satisfactory materials and a relatively clean public sewer, not carrying wastes more noxious than normal domestic foul water. It was considered that intercepting traps increased liability to stoppages, created difficulties in ventilation and added to costs in respect of materials and labour.

(43)
A survey by the Building Research Station has shown that local authorities are spending £100,000 a year to clear domestic drainage systems which have become blocked owing to pipes of too large diameter, unnecessary bends, straight pipes made to form large radius curves, excess jointing material entering drains and the obstruction of the intercepting trap. The provision of intercepting traps in drainage systems has long been a cause of controversy between experts who either want interceptors to be retained or abolished.

The idea of a drainage system based on the theory that sewer air must be separated from drain air hardly bears examination, for surely it cannot be right to assume that it is safe to endure conditions in public sewers that would be inadmissible in private drains connecting with those sewers. This being so, the abolition of intercepting traps would surely mean that building and building maintenance costs would be lowered without prejudice to health, and in fact, may well bring about a much needed improvement in the ventilation of sewers and in the conditions of those that have to work in them.

Egg-shaped sewer sections, usually formed in brickwork used to be popular in this country some twenty or more years ago but this shape is rarely seen now. In view of this it is interesting to note that modern drainage systems in Spain quite commonly employ pipes with an egg-shaped section. A combined system of drainage in the very dry climate experienced in Spain is likely to have long sustained periods of "dry weather flow" and it is probably due to this that many of the drainage and sewer pipes are of this section. On new building sites in the Barcelona area it is usual for drains and sewers to be constructed of precast concrete as shown in the two photographs. Quite often the pipes with an egg-shaped section are down to a diameter as low as 6in. with an invert diameter of about 2½in. to 3in.

Note the "ogee" joint which is used for both circular and egg-shaped pipes. The pipes are one metre in length, or just over three ft. The "ogee" joint would scarcely be tolerated in this country/



country, nor would precast concrete be favoured for drains taking anything other than surface water. But there might well be a case in this country for a return to the egg-shaped section in the interests of more efficient self-cleansing during dry weather periods. It is open to doubt whether egg-shaped section pipes could be manufactured economically in glazed fireclay, particularly in the smaller sizes such as the Spanish builders use for their house drainage systems. Whatever the shape or/ ^{material} of the drain pipes, there is no doubt that the English manufacturers could follow the example set by Spain (and Scotland) of making drainpipes in three ft. lengths instead of two ft. The Scottish manufacturers have produced 3 ft. pipes for a long time now and they are generally found to reduce the time spent in laying and jointing.

A further point of interest concerning the pipes shown in the photographs on the previous page is the flat base piece which is cast integrally with the pipe. This is a great help in the placing, centering and support of the pipe, but it is debatable whether these advantages would justify the cost increase consequent on forming such a base to British manufactured pipes.

Pitch Fibre Drainpipes.

Pipes made of pitch-impregnated fibre were first used for drainage work in America in 1893 and the manufacture of similar pipes for drainage began in this country sixty years afterwards - in 1953. The pipes consist of about 75% pitch and 25% fibre by weight, and although there is an American Standard Specification for these pipes there is not, at the time of writing, a British Standard but one is in course of preparation.

There are quite distinct differences between these pipes and normal ware drainage pipes; pitch fibre pipes have flexibility, they are made in 5 ft. 6 in. lengths and the method of jointing is by tapered sleeves that fit tightly on to the taper on each end of each length of pipe. The flexible nature of the material ensures a drive-in fit/^{that} remains tight. Other differences in this form of drainpiping are lightness, ability to be sawn - the cut end being re-tapered with a special reamer tool, and effective resistance to acids, soil corrosion, hot water, etc.

The outstanding advantage of pitch fibre as a material for drainage pipes is, I consider, its flexibility, for the brittle nature of ware pipes has accounted for many breakages brought about by uneven ground pressures, superimposed loads/

loads and similar causes. Such breakages can cause a great deal of trouble and expense in location and repair and the initial cost of installation can be quite substantial when settlement or movement of any kind is anticipated.

The flexibility of pitch fibre pipes enables pipelaying to be carried out on only a firm bed of earth as a support and there is no necessity for the same rigid insistence on a minimum depth of cover as there is for a ware pipe. The method of jointing represents a further advantage, for joints can easily be made in waterlogged trenches or during conditions of severe frost. Also the simple action of making the joint is such that it requires very little "elbow room" in a constricted trench; this is a great convenience, for the ordinary ware pipe jointing demands a clear trench space on either side of the pipe for effective ramming of the cement-mortar and the final pointing. A further point in favour of the tapered joint is that it is self-centering.

Pitch fibre pipes are manufactured in a wider range of sizes than ware pipes; there is, for example, a 3 in. diameter pipe that should be most valuable for small waste branches (always provided that local authorities can be persuaded to relax the generally accepted minimum of 4 in. diameter.)

~~XXXXXXXXXX~~

A British Standard Specification for Pitch-Impregnated Fibre Drain and Sewer Pipes (B.S.2760;1956) has recently been issued at the request of British manufacturers and potential users of these pipes. This B.S. is substantially the same as the official Standard adopted in America and officially accepted in Canada, and ^{it} sets out the dimensions and minimum requirements for pitch-impregnated fibre pipes, couplings and fittings, suitable for use in the construction of drains and sewers, of sizes ranging from 2in. to 8in. internal diameter.

It is interesting to note that the B.S. provides for a comprehensive range of internal diameters from as low as 2in. and including 3in., 4in., 5in., 6in., and 8 in.; there is no reason why full use should not be made of all these diameters in drainage work according to the particular requirements of each job. For many years now, English contractors have used 4in. and 6in. diameter pipes for ordinary domestic drainage work and 9in. pipes for small estate layouts and the like; few contractors or architects have ever criticised this restricted range of pipe sizes as being sometimes rather wasteful of material and consequently unnecessarily expensive from the point of view of the client. Yet in Scotland a 5in. diameter ware pipe has/

has been available for some considerable time and has made a worthwhile contribution to flexibility in the design of drainage layouts and the saving of cost. The Scottish ware pipe is also made in 3 ft. lengths instead of the 2 ft. length customary in England and the savings resulting from the reduced handling and jointing costs are so obvious as to need no elaboration here, the main point arising from this comparison between pipe sizes in England and Scotland is that

these differences between materials used in two countries so close to one another do, in fact, exist and yet there has never been or seems likely to be any move on the part of the English manufacturers to take advantage of the experience of the manufacturers north of the Border in providing an additional pipe diameter to choose from or an increased length of straight pipe.

After detailing dimensions and tolerances for this full range of pipe sizes the British Standard goes on to stipulate that the "stock length of pipes shall not be less than 5 ft. and not more than 10 ft." and then there are requirements concerning the circular shape of the section of all pipes. A substantial part of the B.S. is devoted to ..

descriptions of a series of nine tests which pitch fibre drain/

drain pipes and fittings must withstand. These tests include chemical tests for disintegration, water absorption tests including resistance to boiling water, tests for heat resistance and flattening and a fairly elaborate beam strength test on a given length of specimen pipe. There is also a test for joint tightness which involves a 10ft. head of water on the joint.

The B.S. recognises the necessity for a Code of Practice on the installation of pitch fibre pipes and in lieu of this an Appendix is devoted to useful notes on the correct method of installing the pipes. These notes are very necessary to anyone handling these pipes for the first time, because the laying and jointing technique is completely different from the traditional method of laying and jointing ware pipes. For example, a backstop must be provided behind the first pipe to withstand the impact of the transmitted force from the hammer driving the wooden dolly against the succeeding pipe. In addition to this it is recommended that alignment pegs be driven in at about 20 ft. intervals, initially to provide a guide for the line of pipes; these pegs remain in position and when the pipes are laid, additional pegs are driven in opposite the alignment pegs to help to steady the line of pipes during driving operations.

Altogether, it seems that this material, when used for underground drainage pipes, has much to commend it, though, like everything that is new in the building industry it has first to overcome a traditional wariness or conservatism. By comparison, the ware pipe would appear to have overwhelming advantages, for its appearance and composition suggest permanence far beyond that of a fibre pipe impregnated with pitch. Indeed, a good ware pipe, barring breakages, is really permanent; moreover the ware pipe with its salt or vitreous glazed outer and inner surface has a smooth and clean appeal from a sanitary standpoint.

On the other hand the pitch fibre drain pipes which have been in use in America since 1893 have shown no signs of deterioration whatsoever and are still giving efficient service. Pitch impregnated fibre coverings have protected electric cables for a much longer period than this without giving trouble.

It is a little early yet to answer the inevitable query concerning the cost of pitch fibre pipes as against the more traditional ware pipes. However the following comparative costs have been taken from a recent contract, (1955), where both ware and pitch fibre pipes were used on the same type of work.

In/

In setting out these costs it should be noted that the ware pipes were laid on a 3 in. bed of cement concrete and after testing were haunched up in concrete, while the pitch fibre pipes were merely laid on a prepared sand bed.

Four inch diameter pipes.

Best stoneware pipes, supplied, laid and jointed, resting on 3 in. concrete and haunched :- 14s.7d. per yd.

Pitch fibre pipes supplied, laid and jointed, resting on a prepared sand bed :- 7s. 1d. per yd.

Six inch diameter pipes.

Best stoneware pipes as described :- 19s.8d. per yd.

Pitch fibre pipes as described :- 13s.3d. per yd.

These figures obviously refer to first class work or doubtful ground where bedding and haunching is considered necessary. Supposing the ware pipes had been laid on good firm ground without bedding or haunching, and the pitch fibre pipes had also been laid without the preliminary laying of a sand bed, then the cost would have worked/

worked out rather differently as follows:-

Four inch diameter pipes.

Best stoneware pipes supplied, laid and jointed,
8s. 3d. per yd.

Pitch fibre pipes ditto - 6s. 9d. per yd.

Six inch diameter pipes.

Best stoneware pipes as described:- 11s. 9d. per yd.

Pitch fibre pipes ditto ... 12s. 9d. per yd.

The following extract is taken from an estimate of cost prepared 18th September, 1956 by a well known firm of Quantity Surveyors for a firm supplying pitch fibre pipes:- (44)

"We estimate that your 4" pitch fibre drain and sewer pipes in 8 foot lengths should cost about 8/1½d per yard run laid complete. This is on the assumption that the pipes are purchased at 2/3¾d per foot run, i.e. that an order exceeding £250 in value has been placed.

Our estimate is made up of 7/-¾d for the pipe including waste delivered to site, 3¾d for labour and 9d for overhead charges and profit. We have no first hand knowledge of the cost of laying the pipe but you will see that a 25% increase or decrease in the cost of labour would only affect the overall price by less than 1d.

We estimate the cost of 4" "best" quality salt glazed stoneware pipes laid complete to be 7/7d per yard run and the cost of "second" quality pipe 6/10d per yard run, so we/

we are in little doubt that pitch fibre pipes would normally be the more expensive, but for the different requirements as regards the bed.

For the stoneware pipes you would normally have a 4" concrete bed, which we estimate to cost 7/5d per yard run, whereas for the pitch fibre pipes it appears that only a 1" bed of sand is required which we estimate would cost 4d per yard run. Taking this into consideration the pitch fibre pipes are considerably cheaper, the cost of the pipe and sand bed being 8/5½d per yard run as opposed to 15/- for "best" stoneware pipes on concrete."

In the second and more recent estimate the cost of the 4" pitch fibre drainpipes is 8/1½d which represents quite an increase on the 6/9d shown in the first estimate. Six inch diameter pipes are not mentioned in the second estimate, but if the list price of 16/4d per yard length of 6 in. pipe is increased, say, by 1/2d for waste, labour, overheads, etc. then the cost would be 17/6d a yard, laid and jointed.

So it seems that pitch fibre pipes might be well worth while in the 4 in. diameter size so long as the comparison is against stoneware pipes laid on concrete. One must also take into account the fact that the specification has taken best stoneware pipes as the basis for comparison on the traditional side. If ordinary glazed fireclay pipes were used, as is usual for housing purposes, the/

the cost advantage of the pitch fibre pipes would be reduced, for the cost of 4 in. glazed fireclay pipes would be approximately 6/-d a yard run against 7/7d noted in the second estimate.

It may be that given a steady demand, the manufacturers could reduce the cost of pitch fibre pipes considerably. Also, when workmen had gained sufficient experience in laying these pipes there should surely be a significant saving in the cost of laying and jointing over ware pipes. It is, however, an unfortunate truth that contractors are not likely to take up a new technique unless field trials have shown the saving in cost to be nothing short of spectacular, and even then it is only the more venturesome who will forsake the old and trusted method for the new.

W A L L SScaffolding.

Metal scaffolding, from the simple tube to the latest forms of unit-frames, has been the subject of steady development since the last war. More and more ingenuity has been applied to the problem of easy erection coupled with quick adaptability to the varying conditions on different types of building sites.

The unit-frames are probably the most useful development in the interests of speed and safety in the construction of scaffolding. There are many different types but they mostly take the form of welded tubular braced frames which are stood upright at right-angles to the wall and joined together by ledger tubes threaded through the frames and fixed by special couplings. The frames can be fitted with adjustable base plates to suit undulating ground.

For small-scale building work these prefabricated scaffold frames are particularly suitable. It is claimed by one firm that a complete scaffold, four frames high, with an approximate platform height of 18 ft. can be easily erected and dismantled by one man in less than three hours/

hours. Such a scaffold is completely independent of the building fabric and does not require to be tied in to the walls, moreover the scaffold can be quite easily erected by the builder who does not employ scaffolding contractors to erect and maintain his scaffolding.

Development work that commenced in 1943 has led to the production by Northern Aluminium Co. Ltd, of an extruded alloy scaffold plank ⁽⁴⁵⁾ which, although weighing/ only 2.06 lb. per ft. run, is capable of withstanding, with a wide margin of safety, a 200 lb. central load on an 8 ft. span. The plank is resistant to corrosion and it is claimed that it can be subjected to general rough usage including dropping from considerable heights.

The advantage of metal planks is undoubtedly that of long term economy, the traditional timber plank is a wasting asset indeed, for the losses from breakages, theft and needless cutting are very considerable. One point of criticism of these alloy planks surely applies to their very lightness. It seems to me that a great deal of additional care is necessary in the layout of scaffolding planked with this new material. All planks would need to be evenly supported and overhanging ends would have to be restricted to a minimum of 2 in. or so, otherwise there would be danger from "jumping" ends of planks.

The "bracket" scaffold seen in the photograph is still used by many contractors, though there is little to be said for it and H.M. Factories Inspectors do not like this form of scaffold.

In this particular instance the scaffold has been put together reasonably well, the horizontal member has been carried through past the stanchion and anchored to it by passing a bolt through the rear parts of the horizontal members.

Usually the bracket is simply thrust against the wall and propped with the

raking shore and there is nothing to prevent the bracket slipping sideways or maybe falling outwards from the wall.

The Scottish contractors often adopt this form of scaffold for work which cannot be done from an internal scaffold, such as external rendering or the erection of eaves gutter, (harling and rhone). The method is rarely in accordance with the requirements of the Building Safety and Welfare Regulations.



Although external forms of scaffolding are the rule in England it is curious that Scottish builders have always favoured the internal scaffold, built up off the interior floors. Reference to this has been made in the background notes to this thesis under the heading " Contracting Methods in Scotland", and there seems little doubt that it is cheaper to make use of the floor joists and to build the walls overhand, rather than to set out a system of external scaffolding and continue it through each subsequent storey. There are of course, many reasons why an external scaffold is desirable in the interests of workmanship, safety and expedience, but the question of cost is, unfortunately, bound to overshadow all other considerations.

In Russia, the method of internal scaffolding is generally practised; boarded platforms are supported on tubular frames at 6 ft. 4 in. centres and this scaffolding is supplemented by trestles at intermediate heights so that the bricklayers work up to a height of ^{only} 3 ft. 9 in. at each lift. In Denmark the economic convenience of the bricklayers is studied to such an extent that a 16 in. wide board at a height of 4 ft. 4 in. runs the whole length of the scaffolding and supports the materials that the bricklayer uses.⁽⁴⁶⁾

The makeshift internal scaffold shown in this photograph is typical of the average housing job in Scotland. Trestles rest precariously on single planks laid on the first floor joists, and the scaffold planks are lapped over the trestles in a manner which ought never to be countenanced in modern building work. How can men be expected to work efficiently and safely on such a scaffold? the planks are all unequal in length so that the 2 in. lapping rise represents a worse danger than if the 2 in. step, undesirable in any circumstances, had been a level one.

There can be no real saving resulting from these slipshod methods of scaffolding. The speed of the operative is adversely affected and the overhand method of building the external walling has, in my opinion, contributed largely to the undisputable fact that Scottish faced brickwork is generally of a lower standard than anywhere else in the United Kingdom.



The Italians have developed the use of timber scaffolding in many interesting ways. The photographs show one method of cantilevering scaffolding at each floor level on tall blocks of houses. Putlogs are anchored underneath runners which are threaded through upstanding hoops of reinforcement that had been purposely built into the floor concrete. The putlogs support the outer scaffold planking, handrail, toeboard, etc., and as the building progresses they can be withdrawn from the upstanding hoop as required. Ultimately the hoops are cut off level with the floor so that the floor surfacing can be applied.



The Italians have to face up to an enforced steel shortage, hence the timber scaffolding. It is possible, nevertheless, that this cantilevering technique might effect economies in steel scaffolding.



W A L L S

Load-bearing Walls of Bricks or Blocks.

Walls built of load-bearing brick have been in common use in England for hundreds of years and though more recently adopted in Scotland the use of the brick wall is now firmly established. Preferences for this or that form of bonding differ slightly between various parts of England and Scotland but in general the same bonding techniques that were common in 1600 are still used today. In housing work the cavity wall is being increasingly used in England, though in the Midlands the 9 inch solid brick external wall is still seen. The cavity wall is fairly general however for all conventional external brick walling in Scotland.

Perhaps the first important move towards economy in ordinary brick walling came when bricks were first made with a single or double frog, thus securing economy through a considerable reduction in the amount of clay used. The finished article was lighter and gave increased lateral wall strength owing to the improved "key" of the mortar joint. Quite recently the manufacturer of Fletton bricks increased the size of the frog in order to reduce weight still further, but this move towards economy has intensified the age-old argument concerning the manner in which a single-frogged brick should be laid, frog upwards or downwards ? If the brick be laid
frog/

frog upwards then the saving in clay through the enlarged frog is offset by an increase of about 12% more mortar in filling up the larger frog. Clearly, if this bid for economy is to be successful from all points of view then the brick must be laid frog down and at the same time the brickwork must be capable of withstanding all the forces which may bear upon it together with a resistance to the weather that may seek to penetrate it. There has been much controversy over this and a Report ⁽⁴⁷⁾ has been issued by the Building Research Station which includes all the available test data on deep-frog bricks laid frog down, and the general conclusion is that the brickwork produced is of sufficient strength for all the normal purpose of house-wallling.

Despite these findings of the B.R.S. there are many architects and clerks of works who will not allow brickwork to be built with bricks laid frog down and it seems to me that this is yet another instance of resistance to change. It is my opinion that this conservatism may discourage other manufacturers from following the example of the Fletton brickmakers who are to be complimented on producing a new form of brick that is bound to effect a saving in manufacturers' costs and moreover, due to greater ease in handling and laying, will help to reduce bricklaying manhours. I consider that those who oppose the practice of laying bricks frog downwards would do well to study/

study the walling methods in other countries where hollow clay blocks of all descriptions, offering far less resistance to wall loadings have been used successfully for many years.

Reinforced Brickwork.

The introduction of metal reinforcement into brick walling, either in the form of bars or mesh, is a technique which is by no means new, yet it has not been widely used in house construction and consequently there is little testing data available in this connection. The object of reinforcing brickwork is either to assist the brickwork to withstand horizontal pressure from either side or to cause the brickwork to act as a beam spanning from pier to pier. In certain of the partition walls in the new Scottish National Library building reinforcing mesh was used wherever the walls exceeded twelve feet in length, unsupported by pier or column and in a number of instances of new construction in factories for the I.C.I. in Scotland I have noticed that horizontal mesh reinforcement has been used to enable wall thicknesses to be reduced.

Reinforcement is particularly useful in light panel walls and is used fairly extensively in large industrial buildings, garages, hangars, etc., where there are large areas of panel walling between framing or piers. The application of reinforcement to house walling however, does not appear to have/

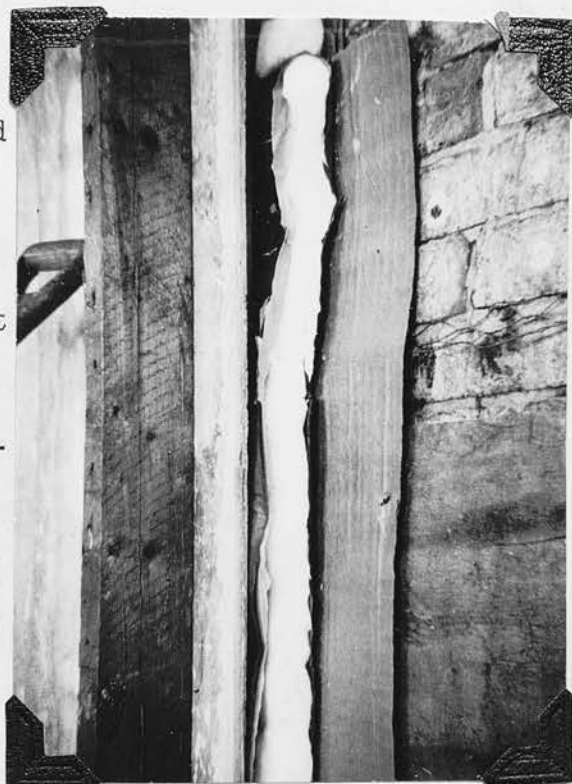
have been fully considered and I feel that there is scope here for testing and research so that the strength, for example, of a reinforced $4\frac{1}{2}$ inch wall built in brickwork may be known for certain within reasonable limits and architects may be thus encouraged to specify light $4\frac{1}{2}$ inch panel walls between carefully sited piers wherever possible. I have recently designed and built a small house in which the greater part of the external walling is $4\frac{1}{2}$ inch reinforced brickwork spanning between brick piers. The piers were about six feet apart and positioned as far as possible so that they occurred at the sides of window openings, at crosswalls, or behind fittings. The inner wall was built after the roof was put on and consisted of a layer of waterproofed paper, a layer of glass wool quilting, then finally a three inch wall of heavy gauge hollow asbestos-cement decking section as shown in the ~~detail on the next page~~ photographs which follow.

It is important to note that the overall panel thickness is only about eight inches complete with plaster skimming. This compares well against a full $11\frac{1}{2}$ inches for a conventional cavity wall with a two-coat plaster finish. This reduction of wall thickness, amounting to seven inches (between two external walls) of valuable room space, is quite a consideration and could easily increase the available area in a 1000 feet super detached/

detached house by 3% to 5%. A further consideration from an owner-occupier's point of view is that the Scottish rating authorities usually base their assessments on overall outside measurements so that the house with masonry walls two or three feet or so in thickness may come off badly in comparison with a house that has panel walls similar to those described above and shown in the photograph. 1

In my opinion reinforced brickwork could be employed much more often in housing work, particularly in the detached and semi-detached types where there is a fair length of external walling. The work must, however, be carried out in a careful and efficient manner to ensure that the reinforcement is completely imbedded in the mortar joint and cannot suffer deterioration throughout the life of the building. The composition of the mortar must be such that there is a low level of porosity in the finished joint; in a series of tests on reinforced brickwork by Professor Hjalmar Granholm of the Technical College Building Research Laboratory, Gothenburg, it (48) was established that the composition and properties of the mortar used for the laying of the bricks played an important part. It was found that it was essential for the mortar to contain an adequate cement ratio, the minimum requirement being a cement:lime:sand mix of 1;1;6. This ensured that the porosity was fairly slight and the mortar consequently gave adequate protection against corrosion of the reinforcement.

This photograph shows the wall construction described in the foregoing pages. There is the single brick wall with a layer of roofing felt against it. After that the glass-wool quilting and then the asbestos-cement inner wall. The upright piece of 4 in. by 2 in. timber is simply a temporary support for the inner wall during fixing. Part of a layer of



reinforcement is seen protruding from the outer brick skin, the reason for this was that the original intention was to build a clinker block inner wall and tie it in to the outer wall at intervals with reinforcement built partly into the outer wall.

The smaller photograph helps to describe the section of the asbestos-cement inner wall which consists of a $\frac{1}{2}$ in. flat inner sheet bonded with a modern resin glue to a $2\frac{1}{2}$ in. corrugated backing.



Walling Built of Blocks.

Blocks of one material or another, of various shapes and sizes, and with a wide range of bonding methods have been launched upon the building industry by sundry inventors over a long period; the years after the 1914-18 War, when bricks, bricklayers and houses were so scarce saw the introduction of concrete and breeze blocks, mostly for partition work, and ever since, the employment of blocks in the place of bricks has increased slowly but steadily.

The main purpose in substituting a block in the place of a brick is, of course, to provide a faster alternative form of walling to that in conventional brickwork, but there may be other advantages resulting from the use of blocks. For example there are many blocks on the market now that provide a remarkably high degree of thermal insulation and are, at the same time much lighter in weight than bricks and consequently effect economies in the sizes of structural members. Again the blocks are often "nailable" and this means that a further saving is possible in plugging labours.

One form of concrete building block recently tested by the Building Research Station is stated to be four times as fast as ordinary brick construction. ⁽⁴⁹⁾ The blocks are designed to B.S. 2028 and measure 18 in. by 9 in. by 9 in., equal/



equal in volume of walling to twelve bricks. There are twelve different types of complementary block units or "specials" and the blocks are manufactured in foamed slag or in "no fines" cellular concrete. Horizontal and vertical cavities provide continuous air spaces to insulate against rapid internal changes of temperature. A thermal "U" value of 0.20 is claimed against 0.47 for 9 in. brickwork.

This test was part of a large scale works study in blocklaying in which ten pairs of houses of uniform design were erected, each pair being built in a different type of block or combination of blocks. The recorded results showed quite a substantial variation between the various types of walling but in all cases there was a saving in manhours on the block walling compared against the times recorded for building one of the ten pairs of houses in traditional brick cavity walling.

(50)
Research in Germany has established that the manhours required for perforated brick or hollow block construction are less than those for ordinary brickwork to the extent of 35% to 40%. These figures are based on analyses of manhours taken to build loadbearing 15 in. thick solid brick walls as compared with loadbearing hollow block walls. The figures 35% and 40% represent the saving in manhours on actual/

actual wall construction and do not take into consideration the further economies in working time that would be likely to result from the easier site handling and transport.

In this German research it was calculated that 2,400 manual operations are necessary together with the walking over 400 separate distances in order to lay 400 standard German bricks. Clearly, it is a waste of human effort for a 10 or 11 stone man to perform all these operations and walk such distances with weights that do not exceed 7 lb. or so for one brick plus a trowel loaded with mortar, and the various Continental countries have appreciated this. In Western Germany the use of light concrete blocks for walling is ~~practically~~ universal; in Neuwied alone there are 1,040 precast concrete firms manufacturing light-weight concrete blocks with a pumice aggregate. The blocks are transported to all parts of Germany and the use of the blocks has grown to such an extent that the brickmaking industry has suffered a most serious decline.

In Sweden, the building industry has been almost completely revolutionised during the past thirty years by the development and extensive use of lightweight concrete. ^(51/52) One of the most popular materials used is called Ytong and is produced from siliceous material and quicklime. The/

siliceous material can be represented by a variety of types of material ranging from sand to fly ash or pumice, and the lime does not have to be of a high quality. Grinding, mixing and high pressure steam curing are the principal manufacturing processes and the finished product may be in load-bearing quality weighing about 45 lb/cu. ft. or in the form of insulating slabs weighing 25 lb./cu. ft. The blocks may be sawn quite easily and all sizes of wall or floor slabs may be prepared and reinforced if necessary by inserting the reinforcement in grooves formed in the edge of the slabs, and filling in with cement mortar. This insertion of steel reinforcement in a highly porous material appears to be inviting trouble from corrosion but it is claimed that no serious damage has been detected in buildings incorporating this reinforced material which have been in use since 1930.

Generally the compressive strength of concrete blocks is not high, the British Standard for Precast Concrete Blocks ⁽³³⁾ mentions a range of compressive strengths from 150 lb./sq. in. to 500 lb./sq. in. according to whether the blocks are for partitions or for rendered external walls.

This British Standard is inclined to be a little/

little incomprehensible, for while it sets out requirements for "precast concrete partition blocks" which include a transverse test for solid blocks and a compressive strength test for hollow blocks, the requirements for "concrete blocks for rendered walls" include only the compressive strength test which is applied to both hollow and solid blocks.

It is difficult to understand why solid blocks for partitions must undergo a transverse test and solid blocks for external walls must be subjected to a compressive test, for surely if a transverse test is necessary for blocks exposed to the loadings normally encountered in partitions then such a test ought to be applied to blocks in load-bearing external walls.

A further curious point about this British Standard is the general heading of "Concrete Blocks for Rendered Walls". One would have thought that the B.S. heading should refer to external walls since, by implication, a rendered wall is usually an external wall. The B.S. does go on to define the scope of the Specification as including external walls protected by rendering or in some other efficient manner, infilling panels in framed buildings and internal backings/

backings to brickwork and masonry, but even then there is nothing said about the external walls - whether they are loadbearing or otherwise. A description of the various permissible aggregates to be used in the manufacture of the blocks is set out in the Specification and it is interesting to note that well-burnt clinker complying with B.S. 1165 is listed among these aggregates, for few local authorities will permit clinker blocks to be used in loadbearing external walls.

In the Edinburgh area, as in many other areas, the modern clinker block is still described as a "breeze block" and is regarded as being different to a concrete block which is generally assumed to be made up from a natural gravel or crushed stone aggregate. As a consequence of this rather inaccurate distinction between types of blocks the clinker block is not favoured for loadbearing walls and many local authorities limit its use to non-loadbearing partition walls.

This conservative attitude of local authorities, this overweighted tendency always to err on the right side, contrasts strangely against well established Continental practice. The Germans have long held the view that owing to/

to the relatively light loadings occurring in domestic buildings the thickness of the wall need be determined only by the required degree of thermal insulation. ⁽⁵⁴⁾ These This view has been supported by the successful ~~views have been successfully implemented by the~~ construction of loadbearing walls in five-storey buildings, using lightweight blocks with a compressive strength of 850 lb. per sq. in.. With wall thicknesses starting at 14 in. and reducing to 10 in. in the upper storeys, thermal insulation "U" values of 0.09 and 0.12 are being obtained.

Lightweight concrete blocks with a minimum compressive strength of 500 lb./sq. in. should prove quite adequate in two and three storey domestic buildings so far as wall stability is concerned, but there must be careful consideration given to the question of moisture movement and moisture penetration, for lightweight concrete is particularly prone to both. The expansion of concrete blocks as they absorb water and a corresponding shrinkage as they dry out may cause considerable movement in a panel of such blocks. This movement may produce widespread cracking which may well bring about serious structural failure or at the very least may involve expense and inconvenience in the renewal of internal finishings.

The/

The test results set out on the next page relate to concrete blocks made from an aggregate containing a proportion of fly ash from Portobello Power Station, Edinburgh. It will be noted that the blocks registered an excessive moisture movement amounting to more than 0.1%. In a wall panel ten feet long the movement would be of the order of one eighth of an inch, enough to cause distortion and cracking in any kind of structure.

In this test the compressive strength of the blocks varied considerably and the three inch blocks were particularly poor. The test results set out on the page following this fly ash block test are more representative of the qualities of a reasonably good block manufactured from a clinker aggregate. Here it is seen that the average compressive strength is 590 lb./sq. in., which is in excess of the B.S. requirements. The moisture movement and drying shrinkage figures are much better than those shown for the blocks in the first test, but they are nevertheless, very close to the B.S. maximum figures.

There remains the problem of protecting these concrete block walls against the penetration of moisture; where lightweight aggregates such as clinker are used the use of a water resistant rendering seems unavoidable, and

BLOCK TEST NO. 1.

The aggregate sample (5 pounds) was prepared for test and tested in accordance with the specification with the following results:-

SOUNDNESS TEST No sign of expansion or cracking in samples (two). Sound

LOSS ON IGNITION

<u>Sample Number</u>	<u>Percentage Loss on 5 hours ignition</u>
1	14.25
2	14.25
3	15.00

The partition blocks were prepared for test and tested in accordance with the specification with the following results:-

COMPRESSION TEST

<u>Sample Number</u>	<u>Size (Inches)</u>	<u>Area of Bedfaces (Sq. inches)</u>	<u>Crushing Load (Tons)</u>	<u>Crushing Stress (Lb/sq.in)</u>	<u>Average Crushing Stress (Lb/sq.in)</u>
1.	18.62 x 4.08 x 7.87	76.00	19.90	586.	436
2.	19.62 x 4.08 x 7.87	80.25	13.20	369.	
3.	19.50 x 4.06 x 7.87	79.10	14.80	419.	
4.	19.62 x 4.06 x 7.87	79.80	13.20	371	
5.	18.50 x 3.01 x 9.0	55.75	3.025	122	190
6.	17.87 x 3.01 x 9.0	53.80	6.00	250	
7.	18.00 x 3.11 x 9.0	56.00	6.10	244	
8.	18.00 x 3.01 x 9.0	54.10	3.53	146	

The 3 inch thick blocks showed various shrinkage cracks before test.

DRYING SHRINKAGE AND MOISTURE MOVEMENT TESTS.

One sample about 8" x 4" x 3" was cut from each of three 4 inch blocks and tested.

<u>Sample Number</u>	<u>Drying Shrinkage Per Cent</u>	<u>Moisture Movement Per Cent.</u>
1	.1413	.1201
2	.1482	.1292
3	.1330	.1190

BLOCK TEST NO. 2COMPRESSION TEST.

The six 4 inch thick blocks received were cut to about 20 inches long and bedded one face at a time with cement: sand mortar (1:1 by weight) such that the bed was not less than one quarter inch thick and the bed faces were plane and parallel. Twentyfour hours after bedding the second face the blocks were immersed in water until the cube strength of the mortar used for bedding that face was not less than 6000 lb./sq.in. when the blocks were tested wet between plywood sheets with the following results:-

Block Number	Size (Inches)	Area of Bed Faces (Sq.Inches)	Crushing Load (Tons.)	Crushing Stress (lb/sq.in.)
1	19.75 x 4.05 x 9.12	79.98	22.10	618
2.	20.00 x 4.05 x 9.12	81.00	22.00	608
3.	-do-	81.00	19.80	548
4.	18.00 x 4.05 x 9.12	72.90	19.30	593
5.	19.62 x 4.05 x 9.12	79.40	22.10	623
6.	-do-	79.40	19.50	550
				<u>Average 590</u>

DRYING SHRINKAGE AND MOISTURE MOVEMENT TESTS

Three specimens about 8" x 3" x 2 $\frac{1}{2}$ " were cut from the 2 $\frac{1}{2}$ " thick blocks and were prepared for test and tested in accordance with B.S. 834 with the following results:-

Specimen Number	Wet Length (Inches)	Shrinkage (Inches)	Percentage Shrinkage	Expansion (Inches)	Percentage Expansion.
1	7.920	.0043	.0544	.0041	.0518
2.	8.025	.0044	.0548	.0039	.0487
3.	7.900	.0041	.0519	.0039	.0494

AVERAGE PERCENTAGE DRYING SHRINKAGE .0537

AVERAGE PERCENTAGE MOISTURE MOVEMENT .0499

LOSS ON IGNITION TEST

Samples were taken from each of the 2 $\frac{1}{2}$ " thick blocks crushed and finely ground and five gramme samples were ignited for 5 hours with the following results -

Loss on Ignition - Sample 1. 9% Sample 2 10% Sample 3 8% Average 9%

A method of building loadbearing walls in precast concrete slabs has been worked out by the Scottish Construction Co. Ltd. ⁽⁵⁵⁾ and used in building many thousands of houses, both in Scotland and in England. The foundations are in accordance with normal construction and external walls and party walls are built up to ground floor level in conventional 11 in. brick cavity walling. Oversite concrete $3\frac{1}{2}$ in. thick is then laid on top of hardcore filling over the entire area between external walls. It is at this point where the precast blocks are introduced, first in a base bonder course acting as a plinth and laid on a felt damp-proof course. Block walling then follows on, a three inch thickness outside and four inch inside with a two inch cavity in between the two skins.

The external blocks are factory produced and are pressed out so that they are hollow on the inner face, and a pleasingly textured and coloured facing is cast integrally with the rest of the block during its manufacture. The facing material which has proved most successful is fine Hopton Wood limestone aggregate, giving a regular texture, cream in colour. Houses built by this firm in the Edinburgh district appear to be retaining their colour remarkably well after several years' exposure. When seen

"en/

"en masse" the colour is naturally a little monotonous but it is infinitely better than the dreary acres of drab harled walling that covers so many of the houses in the Scottish housing estates.



The photograph shows the general effect of this type of block walling in a typical Edinburgh housing estate. The colour is a light cream and the texture and various shapes of the blocks can be examined more closely in the photograph below. The method of employing a block



with a return is quite interesting and is effective, both from the point of view of bonding and appearance.

The use of the vee-shaped projection on two edges of each slab together with a deep groove in the opposite edges of the block ensures a good bond between courses and the hollowing out of the backing during manufacture saves

material and makes for easier handling.

A building block which is very similar to the Swedish product Ytong has been produced in this country by a subsidiary firm of one of the largest contracting organisations in Britain. The material is called Thermalite, and is manufactured in standard building blocks of nominal face dimensions 18 in. by 9 in. in various thicknesses and is of adequate strength to carry normal floor and roof loads. It has a density of 50 lb. per cubic foot which is less than half the weight of normal concrete and yet it has a cube compressive strength of 750 to 800 lb. per sq. in. The thermal "U" value for two 3 in. leaves with normal finishes is 0.15.

In a works study on laying rates carried out by a reputable firm of management consultants it was established that operatives of normal competence working on ordinary two-storey houses in cavity construction achieved an overall non-bonused rate of 21 blocks per bricklayer hour. This rate was for all work and included setting lintels and fixing window and door frames; proper relaxation and fatigue allowances for the heavier type of work were made when computing the rate of 21 blocks per hour.

~~The labour cost per yard super of Thermalite~~
~~blockwork/~~

It seems likely that the use of concrete or clinker blocks will remain an established technique in wall construction, perhaps as much for the thermal insulation value of the blocks as for the advantage of speed in wall construction. But there is one potential advantage in the use of block walling which, I consider, has never been fully appreciated by manufacturers - I refer to the advantage that would result from the production of a block with an absolutely regular single or double side with a smooth face which could take a very thin skimming coat to hide the joints. This has been tried out but only in a limited way, some manufacturers have produced blocks with a plastered surface put on during the casting of each block and I have seen a few blocks partially composed of "fly ash" that appeared to be very regular in shape and to have quite a clean close-textured face.

I consider that the reduction of the plaster thickness in wall finishings is a great aid to economy and given block walls that can be built to fine limits, it is possible for the plaster thickness to be cut down considerably. I have myself built walls of locally manufactured clinker blocks to limits that have been sufficiently accurate to permit a $\frac{1}{4}$ inch backing coat to be applied to the wall without any trouble at all except for a little finer sifting of the sand in the cement:lime:sand mix.

Hollow Clay Blocks.

Hollow clay blocks have been used in this country for sixty or seventy years . They were initially used for floor construction by combining them with reinforcement and concrete in the early patent floor systems. The use of these blocks for walling purposes has developed fairly steadily since 1920 but not nearly to the same extent as development has been in other European countries, where they tend to be used considerably more than ordinary bricks.

It is a little difficult to understand why the Continental preference for hollow clay blocks is not shared in this country. We have plentiful supplies of clay which is quite suitable for extruded clay blocks and there are reasons for building in hollow blocks that can scarcely be disputed. They are much lighter in weight than standard bricks for a given unit of walling, and this makes for economy in manufacture, easier handling and transport. Thermal and sound insulation are better and it is obvious that the large unit size of the blocks will enable a bricklayer to accomplish an increased volume of walling in a given time than he can in standard bricks. Every time one block is laid there is the equivalent of three ordinary bricks and more than this, there is the saving of two courses of mortar which is quite a significant saving in a large housing scheme.

I am assured by British manufacturers of hollow clay blocks that in their own local areas their blocks are cheaper initially to buy than bricks.⁽⁵⁶⁾ I have also been given first-hand information by a Direct Labour organisation to the effect that the Building Manager has obtained a cheaper rate for walls built of blocks as against bricks.

This " off site " information is often more informative than long term scrutiny of builders' tenders can be, for there is a tendency in these times of full employment for builders to accept an unlooked for saving as something to be pocketed as a little personal bonus to be set against some future " unlooked for " loss.

The increased thermal insulation of walls constructed of these blocks can also be translated into terms of hard cash; according to this extract from a letter sent to me by a responsible representative of the manufacturers of the "Eecon" hollow clay blocks⁽⁵⁶⁾ :- " The occupier of a house built with the internal leaf of hollow clay block must save on his fuel bills throughout the year, due to the fact that the insulation value, which is virtually free, does tend to make him burn less in his house to keep it at a comfortable temperature. To illustrate this we were informed by the Heating Engineer in the Saughton School in Edinburgh, which is/

is built entirely of hollow clay blocks, that the increased thermal insulation of the building had enabled him to save something like £200/£300 in heating equipment."

British Standard 1190;1951 specifies hollow blocks manufactured from clay for the following applications:-
 Section(i) For use in internal walls (loadbearing and partition)
 Section (ii) For use in structural floors, roofs, mansards and analogous construction.

These sections deal with dimensions, tolerances, crushing strength. etc., the minimum crushing strength requirement for blocks in loadbearing internal walls is 500 lb. per sq. in. and the few manufacturers in this country have no difficulty in producing a block that meets this requirement. It is significant that there is no B.S. for hollow clay blocks in external loadbearing walls so far as crushing strength is concerned. Maybe if more external walls were built in these blocks then the British Standards Institution would feel that there was a need for a Standard Specification. Unfortunately the lack of standard requirements for crushing strengths for blocks in external loadbearing walls creates a situation where the local authority may set itself up as the sole arbiter as to the suitability of blocks in these circumstances.

In general, local authorities are reluctant to accept hollow clay blocks for external walls, even when the crushing/

crushing strength is beyond question. This reluctance appears to be due to a general lack of confidence in the weather-resistant properties of the blocks. It is, of course, quite true to say that buildings in Britain are often called upon to withstand weather conditions that are rarely experienced in, say, Italy or Spain where clay block walling in certain types of buildings is left exposed. But if hollow block walling in this country is carefully jointed and then given a proper rendering in cement-mortar or cement-lime-mortar, there is no reason why such walling should not give complete satisfaction. It is important that the jointing between blocks is skilfully done so that the mortar joint is not continuous through the thickness of the wall. This requirement may seem a little at variance with the old fashioned insistence on solid crossjoints in walling., but it has long been proved that in solid brickwork, leakage through the mortar joints is usually the main source of penetration.

It seems fair to say that there are substantial technical advantages to be gained in manufacturing hollow clay units instead of solid units and also that there are other advantages enjoyed by the user. The slowness of development of hollow clay blocks in this country would appear to reflect a certain prejudice or disinterested attitude of mind in both local authorities and contractors.

In Spain, great use is made of hollow clay blocks for all kinds of walling and floor construction. Non-load-bearing partition walls are almost invariably built in these blocks and quite often the thickness of the block used for this purpose is no more than four centimetres. In many instances of stair construction it was most interesting to see an ingenious arrangement of these hollow blocks as arched supports for the actual stairways. This picture is rather dark but



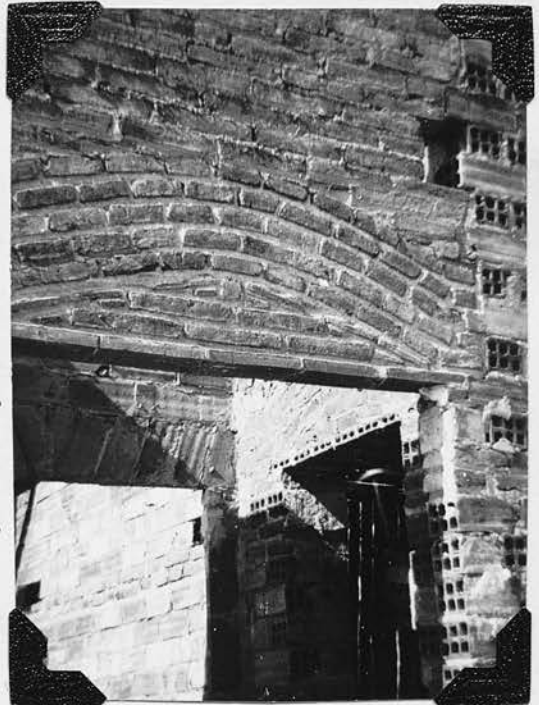
there is perhaps enough detail to illustrate the method of construction. The blocks are laid flat, in courses over a temporary arched support, and then reinforcement^{is placed} in the joint along the line of the arch. The whole is flushed up with cement mortar and the steps are built up in hollow blocks and rendered over with cement mortar. Once the first arch is completed at the base, the remainder of the arches supporting the stairway all the way up through several floors are built in the same way, springing from landing to opposite wall, the landing being simply a levelled space on the arch below./

below.

Sometimes these supporting arches are made up from prefabricated arched beams, using specially shaped blocks, but the in situ method is more commonly used.

The finished staircases appeared to be quite capable of withstanding the loadings normal to a 3 ft. wide flight of stairs in ^a block of flats and I was assured that this method had been employed for many years without a single instance of failure.

The Spanish builders certainly appear to take all kinds of liberty with this material and with ordinary brickwork also. This picture shows a remarkable example of confidence in the ability of a flat arch to support itself and the core of brickwork below the relieving arch. And



in the background can be seen a form of Welsh arch built in 4 cm. thick hollow clay blocks over a 4 ft. 6 in. opening in a partition! Although there is a case for a more imaginative attitude towards walling methods in Britain, this might be considered to be going too far.

Load-bearing Cross Wall Construction.

Increased use is being made now of a constructional technique in which the cross walls of a building are made to carry floor and roof loads while the external walls merely serve as a cladding. This kind of thing has of course, been done for many years in the two-storey terraced house where the chimney breast and a nine inch party wall formed the main cross walls, with an infilling, back and front, of bay windows and timber studding.

The main disadvantages of these early forms of cross wall construction lay in the fact that the timber first floor joists were necessarily supported on the cross walls and in the absence of special precautions the joist ends of adjoining houses were very close to one another if not actually touching; and this reduced sound insulation considerably while it increased the fire hazard.

The inherent structural weakness of cross wall construction due to the absence of the bracing or lateral restraint of the external walls was rarely considered and it was perhaps fortuitous that the window infilling usually fell a little short of the clear distance between cross walls and thus made it necessary for a short return wall at the end of each/

each cross wall, ~~and~~ consequently providing a reasonable measure of lateral restraint.

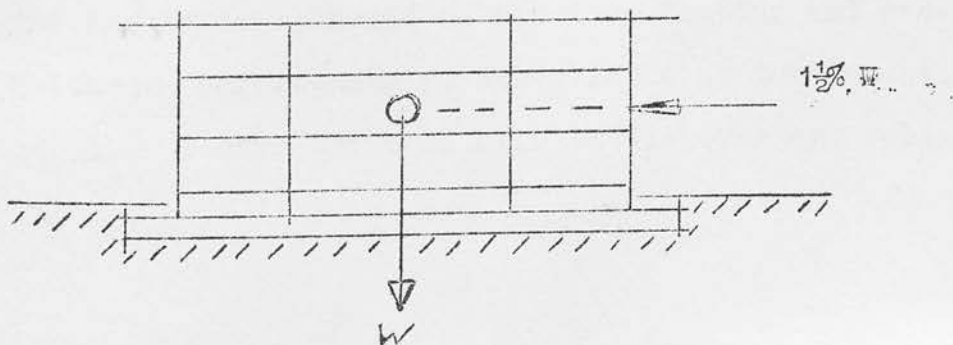
It is this problem of restraining buildings, composed only of cross walls, floors and roof, from collapsing like a pack of cards, that has preoccupied the minds of architects and engineers and has, in many cases, prevented local authorities from accepting proposals for buildings employing this form of construction.

The chief advantage of cross wall construction is that it simplifies the design of the external wall which can then act solely as a curtain wall combining the several functions of cladding, daylighting and thermal insulation without the added complication of structural necessity. Other advantages lie in the simplification of the construction of the building and the increased opportunities for poured concrete walls within large storey height shuttering units placed easily in position by the modern crane. Cross wall construction is ideally suited to large blocks of flats where a simple layout is repeated throughout the block. Wherever possible the staircases should be designed so that they contribute towards the lateral bracing of the building.

The disadvantage of this system where it is applied to multi-storey blocks is that the cross walls must maintain/

maintain their position throughout the structure and there is thus little opportunity for an architect to provide a variation of accommodation within large housing blocks. Another criticism that has been made of the system is that prefabricated external wall sections demand fairly small tolerances in order to be successful and it ^{is}/not always possible to ensure that cross walls are built to a limit of, say three eighths of an inch either side.

Cross wall construction appears to be gaining favour now and is being incorporated in an increasing number of housing projects in this country. But there is still a great deal of variation in the attitude of local authorities' surveyors to this form of construction and it seems unfortunate that a national standard or guide to designers cannot be laid down. Such a standard has already been laid down in the (57) Danish building regulations and it simply requires buildings based on cross wall construction to be so designed that they will safely withstand a force equal to $1\frac{1}{2}\%$ of the total weight of the building, applied horizontally at the centroid of the building as shown in the line diagram below.



The lateral force equal to $1\frac{1}{2}\%$ W imposes a bending moment on vertical cross walls with a consequent increase of stress intensity on the foundation according to the direction from which the $1\frac{1}{2}\%$ lateral force may be deemed to operate. It follows from this that Danish engineers must design foundations with a "spread" sufficient to cope with this hypothetical loading, and when they have done this the local authorities in all regions of Denmark are bound to be satisfied on the point of lateral stability.

A Code of Practice embodying similar regulations would give much needed guidance to local authorities in this country and I consider that additional foundation costs would be more than saved by the economies resulting from the simplifications of cross wall construction. My own view is that the lateral collapse of buildings constructed on this principle is extremely unlikely because there are so many factors in the complete building which, of themselves, contribute immeasurably to the stiffening or longitudinal bracing of the building. Whatever method of control is exercised by the authorities concerning cross wall construction the regulations should be based on testing and research data which are, unfortunately, unavailable at the moment.

I have not been able to discover any reliable data
on/

on the comparative costs of cross wall construction as against the more orthodox forms of construction. Like most new techniques this system of walling has been tried out by only a few of the more enthusiastic and venturesome designers and it must be some time before a sufficient number of projects has been completed and all costs assessed and compared with those of similar buildings built in a conventional manner.

High Load-bearing Brick Walls.

The British Code of Practice for load-bearing walls - C.P. 111/1948 permits a wall design in which load-bearing brick walls may be built three storeys high at a uniform thickness. The Code specifies maximum slenderness ratios for load-bearing walls with various provisions for lateral restraint from floors and return walls. It is thus possible to build higher walls of uniform thickness so that economies in brickwork are secured and there are further indirect economies from the space savings on the lower floors due to the reduced wall thickness.

The Dept. of Health for Scotland built a block of three storey demonstration flats at Sighthill, Edinburgh in 1954 with the intention, among other things, of illustrating the economies in brickwork permitted by the 1948 Code of Practice. (58)(59)

Practice. The external and party walls were of eleven inch cavity brickwork and the partitions which applied the necessary lateral restraint were of $4\frac{1}{2}$ inch brickwork. The floor construction was used to assist the restraint of the walling by incorporating long metal straps in the brickwork and tying them into the joist system. The ceiling heights adopted were 7 ft.6 in.; this reduced the slenderness ratio and, at the same time was in line with the Department's space-saving policy.

During the construction of these demonstration flats the structural engineer responsible for the design of the brick walling took pains to see that the whole of the main and return walls were bonded together as the walls were erected. This meant that toothings, block bonding, indents, etc., were strictly prohibited and as a consequence of this there was a certain amount of additional work entailed in distributing the bricklayers over all walling at each storey instead of the usual concentration of the gang on a few walls at a time.

In order to avoid additional stressing due to eccentricity of loading, the floors and roof loads were carefully planned so as to fall as evenly as possible on the brick walling. In addition to this, great importance was attached to accurately plumbed walls and the engineer and clerk/

clerk of works very sensibly arranged site meetings with the bricklayers and carefully explained to them the reasons for the requirement for accurate plumbing. As a result of this, little or no difficulty over plumbing or bonding was experienced throughout the entire construction.

The saving of bricks resulting from the use of this technique of slender walling was considerable and it was estimated that four flats could be built with the same number of bricks taken to build three flats with conventional wall thicknesses. The cost of each house came out at about £1,397 and while this figure represented little or no saving against comparable housing with orthodox walling the Department felt that there would be a substantial saving on a larger scheme based on one plan form only instead of the two different plan forms in this first experimental block of eighteen flats.

The Direct Labour organisation of the Scottish Special Housing Association erected these flats and from the information given to me by their chief surveyor I consider it very likely that a larger scheme of flats on similar lines would result in a marked saving in cost. It appeared that, as one would expect in all experimental work, the smooth continuity of erection was interrupted many times owing/

owing to modifications of plan, method, etc., with consequent increases in cost. Profiting by this useful experience in slender wall construction the Department is now erecting four storey maisonettes based on similar lines but with emphasis on the complete pre-planning of the entire project by a Building Group. The Group includes a nominated contractor, structural engineer, quantity surveyor, the Department's architects and a representative from the Scottish Building Research Station.

From the enquiries that I have made it does not seem that the Department intends to carry out any day to day site costing and analysis of the new walling technique in order that it may be compared with the more conventional forms of brick walling used on similar buildings. It can be well appreciated that such site costing does involve a large number of observers and a great deal of routine notation and analysis together with the full cooperation of the contractor with daily access to his records. But it does seem unfortunate that this opportunity for the site analysis of the cost of an entirely new constructional technique is to be lost. It will be interesting however, at the end of the contract to see if the quantity surveyor member of the Group has had an opportunity of comparing his original estimate of the nominated contractor's costs in regard to the walling.

No/

No doubt the contractor will take care to see that he has his own private stock of comparative data on the new method of walling so that he is not obliged, as he has been on this occasion, to submit to the quantity surveyor what amounts to a blind estimate of the cost of a block of flats involving a new technique of construction of which he probably has had no previous experience either from the point of view of cost or method.

Consider the dilemma of the quantity surveyor when he has to recommend approval or otherwise of a tender submitted by a nominated contractor for this work. He also has little guidance from previous contracts and since the contractor is in the same quandary and, moreover, is not competing with other contractors, then the surveyor must be prepared for a tender which leans rather heavily on the contractor's side. And in the final analysis, owing to the absence of independent site costing, it will most likely be the contractor alone who will know precisely how much more or less the new technique has cost, over and above normal construction.

Perhaps before these notes are summarised the work on these four-storey maisonettes will have been completed and there may be an opportunity to write a little more about the lessons which have been learned from this new and interesting use of slender brick walls in high buildings.

(When these notes were completed in Dec.1956 this Dept. of Health project was still in progress.)

Walls Built of Large Prefabricated Units.

The limitation on the size of a wall unit is usually that imposed by the capacity of a workman to lift the unit and place it in position without mechanical means. Once the principle of mechanised power is introduced this limitation is removed and the size of wall unit may be increased up to the capacity of the lorry that transports it on to the site and the mechanical hoist which places it in position. At this point however, another factor - the cost of transport and powered hoists has to be taken into consideration where large prefabricated wall units are contemplated, and quite often it has been found that the saving anticipated from the use of large wall sections has been lost through the additional expense of transport and mechanical plant.

Nevertheless, production costs for traditional methods of reinforced concrete construction, with all the expense of intricate shuttering etc., favour the use of large prefabricated panels and of the large number of prefabrication systems adapted to this end I consider that the "tilt-up" wall technique to be the most promising from an economical standpoint. In this system, the wall panels are cast in a horizontal position on each successive floor of the building.

The advantages of this method of site prefabrication are/

are fairly obvious - the floor serves as a base for the formwork which needs to be only on the bottom side and may be of light hardboard panels with braced side frames round the edges; all fittings, fixings, window openings, etc., are readily inserted or formed while the wall is cast and a plaster coat may even be applied while the wall is in a horizontal position. The overriding advantage is however, the dispensation with the need for transport between prefabrication factory and site with all the additional costs of handling.

After site casting the wall unit can be placed in position by the direct lift of a crane but there are certain advantages in tilting the wall into position as against the direct lift. This "tilt-up" technique has been used in America as early as 1910 and since 1945 increasing use has been made of this system, particularly in the Los Angeles area⁽⁶⁰⁾ where large wall units measuring up to 1,000 sq. ft. in area and thirty tons in weight have been tilted into position. Quite recently, for the first time in Norway a block of flats⁽⁶¹⁾ was erected in which all load bearing cross walls were precast on the floor slabs and tilted into position. In this instance three types of wall section were prefabricated (i) the interior loadbearing cross walls, (ii) the external walls and (iii) the non-loadbearing partition walls. The external/

external walls were prefabricated on a prepared base clear of the building and it is interesting to note that up to four wall sections were cast, one on top of the other in a tier form with thin separating membranes between them. These reinforced concrete external wall sections were only about four inches in thickness, fixing battens, etc. being inserted during the pouring. After erection a mineral wool insulation matting and an asbestos-cement outer sheathing were fixed to the wood inserts on the external face of the wall.

At first sight the placing of a thermal barrier on the outside of the wall seems opposed to the normal principles of thermal insulation. The explanation given for this was that the thermal insulation was thus continuous around the entire building and so avoided the usual breaks where cross walls, partitions, piers, etc., were joined to the external walls. Further it was argued that the mass of concrete adjacent to the room would act as a heat reservoir, so that sharp temperature changes were avoided and heating conditions generally improved. It was also claimed that a wall insulation on its inner face will be directly exposed to precipitation, preventing it from completely drying out - the insulation medium then tending to deteriorate through moisture penetration.

I must confess that I cannot follow this line of reasoning, for these external walls were stated to have been given a protective sheathing of asbestos-cement that should surely ensure a dry wall, otherwise why use it ? Moreover, with such a small wall thickness of four inches it might be admissible to let the wall act as a heat reservoir but I am rather inclined towards a cavity, no matter how narrow, between the inner face of the wall and an insulating medium situated on the inner side of the cavity.

The external wall sections, when cured, were moved from the casting base to erection position by the primitive but nevertheless effective method of a sleigh pulled by a capstan wire from a tractor. Considering the state of the average building site in the long winter season there is much to be said for this simple method of transporting large heavy sections over trackless areas though it is possible that the sections might suffer a little damage from abrasion or soiling.

After the external wall sections were hauled to the point of erection they were hoisted into place between the load bearing cross walls that had already been raised by the "tilt-up" method. It is interesting to note that the external wall sections were raised without recourse to a crane; instead/

instead an ingenious hoisting arrangement was made by using a wire rope from a capstan operated tractor situated on the site. The wire rope was passed over a pulley hung out on a derrick mounted on an upper floor in a central position over the particular opening. The stresses communicated through the frame of the derrick were spread over horizontal steel beams resting on the load bearing walls.

This tractor winch hoist was also used in tilting up the cross walls and altogether the whole of this large prefabricated building with all its heavy sections was completed without the aid of a crane. It was found that a maximum of 2.5 manhours per sq. metre of wall area was taken up in prefabrication, transport and erection, including the finishing of the walls ready for decoration. This cost was considered to be roughly equivalent to normal in situ walling without plaster finishing. So the cost of plastering (about £50 per house in this country for interior walling) was the measure of economic attainment resulting from this particular walling technique. In addition to this saving there was the difference between tractor hire and the hire of an expensive crane and more than this there was a distinct saving in the amount of cement used in the walling owing to the increased/^{amount} of horizontally cast walling with the consequent lowering of the water/cement ratio.

This/

This "tilt-up" technique of wall erection was the subject of an official report issued by the Norwegian Building Research Institute and favourable comment was made in it concerning this form of construction. There are, I think, one or two limiting factors worth considering; it is essential for structural stability that the floor slab is poured monolithically in situ so that the prefabricated walling is rigidly restrained at each floor level. This leaves only the vertical wall joints between wall sections to be made good, hence it is best to precast the vertical walling in as large units as possible within the capacity of the tilting machinery or crane in order that the number of joints may be reduced to a minimum. This is where the "tilt-up" technique is most advantageous, for the lower edge of the wall always rests on the floor slab, consequently the tilting machine has only to raise half the total weight of the wall.

One limitation of the technique can be seen at once, for if the walls are to be cast immediately adjacent to their final position then some of the walls are bound to be extremely difficult to place into position owing to the obstacle presented by the walls already erected. This difficulty might not arise on the ground floor of course, where the walls forming that storey can be cast so that the final and most difficult sections can be tilted from the outside.

This/

This prefabrication of walls by precasting on the floor slab of the building has interesting possibilities, for all kinds of finishes such as glazed tiles, vitreous enamelled steel sheets, terracotta, etc., could easily be incorporated on either side of the wall during casting. This could, of course, be done quite as well in the case of concrete wall sections prefabricated off the site but the weight of the sections and the risk of damage during transit would, I feel, rule out the incorporation of the finer finishings.

The prefabrication of large wall units in six, eight-storey blocks of flats has recently been tried out in Sweden.⁽⁶²⁾ In this instance certain of the walls were cast in situ and the prefabricated units were lifted into place by one of three large cranes. Each block was divided on plan into ten cells of equal size by four loadbearing crosswalls and one longitudinal wall, also loadbearing; all these walls including the loadbearing inner skin of the two gable walls were cast in situ.

The technique employed in casting these walls was interesting - the walls surrounding three sides of each cell were poured at the same time by using uniform shuttering units forming one cell at a time, the crane moving the entire box form from one cell to another. The constructional advantages/

advantages deriving from the division of the building plan on an eggbox basis are thus readily appreciated.

The remainder of the walls were prefabricated on the site in sizes corresponding to the openings between the "in situ" walling; normal sizes were about 9 ft. high by 13 ft. long and $3\frac{1}{2}$ in. thick. These sections were cast on special timber forms giving a vertical reeded or corrugated finish to the external face that was left untreated as from the formwork. Cork strips were inserted in the edges of the floor slabs and at the meeting points of the "in situ" walls so that thermal movement could take place and a groove formed in the face of the joints permitted external pointing in cement mortar. A light wood framing was fixed on the inside of all external wall sections providing a fixing for insulation panels and plaster-board making up a 4 in. thickness.

To avoid undue bending stresses in the large prefabricated panels during lifting, care was taken to raise the wall, complete with its formwork, to a vertical position before relinquishing the support of the formwork. The time taken to lift and place one of these external wall sections in position was about 40 minutes and, together with the "in situ" walling it was estimated that two storeys could be built every ten days provided the work could be spread/

spread over two separate blocks.

This experiment has shown that large prefabricated sections can be fitted together with a degree of precision not often experienced on a building site. I feel rather critical however of the method of fixing a wooden framing immediately behind the $3\frac{1}{4}$ in. thick outer walling, for this form of construction suffers from the same weakness that is inherent in the old Scottish method of fixing strapping behind external walls, where occasional moisture finding its way through the wall is in direct contact with woodwork and all too often sets up dry rot. I am doubtful whether this $3\frac{1}{4}$ in. precast concrete wall will prove sufficient in itself to protect the wood framing and in view of this I feel that the small cost of a light impervious lining, if only building paper, would have been fully justified.

It will be interesting to see how the method of jointing the prefabricated sections works out in practice, a wall section 13 ft. by 9 ft. is indeed a large unit and thermal movement may be considerable. It is quite possible that the cement mortar jointing may craze or crack, but the cork should keep the joint watertight. There is little doubt in my mind that this form of construction adopted in these eight-storey flats will prove to be thoroughly/

thoroughly stable, for the "in situ" crosswalls together with the longitudinal spine wall and a poured concrete floor should provide a perfect structural combination with the prefabricated external wall sections.

Large prefabricated wall sections are being factory produced in Argentina ⁽⁸³⁾ and it is claimed that they are suitable for all types of construction whether one, two, or multi-storey. The sections consist of a hollow clay block filling surrounded by a framing of reinforced concrete and are complete with aluminium window frames, electric ducting together with external and internal wall finishes. There is also a special prefabricated sanitary panel in which all water piping, waste pipes, etc., are built in.

Comparing this system of factory produced wall sections with other systems the main point of differences are (1) the combination of hollow clay blocks and reinforced concrete framing which reduces weight considerably and increases thermal insulation and weather resistance, and (2) the technique of placing the prefabricated panels in position first, together with steel forms at the angles and various meeting points, so that the concrete joining up the panels is poured forming a loadbearing frame giving monolithic stability throughout.

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The floor and roof slabs are similarly prefabricated and joined together by reinforced concrete so that the amount of work on the site is reduced substantially. The accurate placing of the panels together with the provision of temporary supports would, I imagine, require considerable skill and care, and for multi-storey construction the crane would have to be mounted independently of the building. The usual criticism that applies to techniques involving large factory made units is bound to apply here, for clearly, a factory such as this in Argentina, making every component part from washbasins to flights of stairs, must occupy a permanent position that will, by its permanence, restrict its field of operations to the economic distance over which its products can be transported.

This limitation imposed by economic transport considerations applies to almost all systems of factory prefabricated houses. In Scotland in particular there are many examples of this owing to the widely scattered townships outside the great conurbations in Central Scotland. Moreover, the isolated geographical position of Scotland itself places further restrictions on the trial of new housing methods originating in England and involving transport from English factories.

Poured Concrete Walling.

Various methods have been used to produce concrete walling cast "in situ" since reinforced concrete came into use in this country more than half a century ago. The better known methods involve the use of wet-mix concrete within shuttering and of these the no fines type of concrete is by far the most popular method at the present time. During the inter-war period no fines concrete was used in England and Scotland but it is the post-war years that have witnessed a marked increase in the use of this material as a structural and insulating walling in housing schemes.

Compared with ordinary dense concrete, no fines concrete has many advantages. To begin with its weight is only approximately two-thirds of the weight of ordinary concrete due to the absence of fine aggregate. This saving in weight together with a corresponding saving in weight of absorbed water during placing results in a lower hydrostatic pressure on the formwork, and as a consequence of this, pouring can continue for greater heights than is possible for normal concrete.

The cellular structure of the concrete ensures a high standard of thermal insulation and at the same time the regular/

regular voids in the concrete reduce the capillarity of the wall. Against these advantages the tensile and shear strength of no fines concrete is low in comparison with ordinary concrete so that it cannot stand up to exceptional bending stresses or eccentric loadings. Walls are usually a minimum of twelve inches in thickness and openings and foundations have to be carefully planned to avoid the possibility of overstressing the concrete.

In Germany the problem existing after the war of utilising the enormous quantities of building rubble in the reconstruction of bombed cities was largely solved by using no fines concrete in multi-storey buildings. The aggregate was usually crushed brick screened to sizes between three eighths and three quarters of an inch, care being taken to exclude the harmful gypsum content of the rubble which, fortunately, was usually located in the discarded fine siftings. The Germans have hitherto been in advance of British designers in applying the no fines concrete technique to walls exceeding five storeys in height. The highest building erected in Germany in this material is the "Max Kade House" in Stuttgart⁽⁶⁴⁾⁽⁶⁵⁾ - this was a 19-storey students' hostel, the upper 13 storeys being of no fines concrete. The walling to the lower storeys was constructed of reinforced gravel concrete in the first four storeys/

storeys and unreinforced brick aggregate concrete in the succeeding two storeys.

In this country no fines concrete walling has been used extensively up to heights of four and five storeys but in only a few instances has this type of walling been applied to higher buildings other than as an infilling material in conjunction with a structural frame of reinforced concrete. However, the Scottish Special Housing Association is now building a ten storey block of flats in the West of Scotland, in which all load bearing walls are in no fines concrete from ground floor upwards.

No fines concrete was used on eight-storey flats recently completed at Kirkaldy⁽⁶⁶⁾ but only as a panel filling between the reinforced concrete frame. An interesting feature of the construction was the use of the no fines panels as shuttering for the soffits of the in situ beams and also for the sides of the reinforced concrete columns. This resulted in an appreciable bond between the r.c. frame and the no fines concrete and the effect of this bond was taken into consideration in the design.

~~The shuttering for no fines concrete buildings represents a high proportion of the cost of the work. The Scottish Special Housing Association and other large contracting firms have experimented with a number of different~~

The high capital cost of extensive shuttering for poured concrete wall construction constitutes the great disadvantage of such walling. Metal formwork systems of all sizes and shapes have been designed and manufactured and are widely employed in the industry. But these shuttering systems are all very expensive in initial cost and a contractor must carry a large stock of it or hire it. If wood shuttering is used then maintenance and replacement costs are high without reckoning the initial cost of the softwood.

Although stock systems of formwork generally include a wide range of complementary interlocking units of various shapes and sizes it is remarkable how seldom a contractor can shutter a complete building without the necessity arising for some purpose-made forms. This is yet another instance where modular coordination would encourage the formwork manufacturers to design to a module and thus prevent the ever recurring expense of odd sections of shuttering.

An extremely interesting technique of shuttering was recently applied in the construction of a 14-storey block of flats in Hamburg, ⁽⁶⁷⁾ where a specially designed form of climbing shuttering was used to contain the poured concrete walling which was reinforced and loadbearing. The climbing shuttering consisted of working platforms on the interior of the/
the/

the walls, anchored to yokes which clamped the shuttering to the walls. The platforms and shuttering were in turn connected to climbing tubes about one inch in diameter which were centrally placed in the walls and went down to foundation level. ~~The diagrammatic sketch on the next page illustrates the method in which hydraulic jacks grip the outside of the tubes and force the formwork and working platform upwards.~~

As the work proceeded two service towers of scaffolding were erected at each end of the building. One tower served as an access staircase to the working platform while the other contained a 15 cwt. platform hoist of the normal type. The concrete was hoisted in the usual continental two-wheeled barrows. The remarkable feature of this system of construction was the speed at which the building rose. The climbing jacks were all operated simultaneously by an electrically driven hydraulic pump and the shuttering rose continuously, day and night, at the rate of about seven inches every hour so that the walls, internal and external to all 14 storeys were poured in ten days.

Recesses for floor beams and openings for windows etc., were formed as the work proceeded and the working platforms were left temporarily in their final position to act as a shelter while all the floors were installed.

The/

The cost of the climbing shuttering equipment was such that a minimum height of eight storeys was considered essential in order to justify its use and the designers calculated that there would be a saving in cost of at least $1\frac{1}{2}\%$ over a similar building framed in reinforced concrete or steel. Other savings in cost were reflected in the gain in floor area through the reduced thickness of the walls compared with normal masonry as was originally intended for this building. Of course the main contribution towards economy was intended to be achieved through the remarkable speed at which the walls were completed. Unfortunately a period of severe and prolonged frost, shortly after the walls and floors were completed, brought the work to a standstill and prevented the full realisation of the economies that had been expected.

It was very difficult to arrive at any cost comparisons for this technique of poured concrete walling within climbing shuttering because, like many similar prototype buildings, no detailed site costing was undertaken. The contractor kept his own records for labour expenditure and some of his figures are set out on the next page. It will be seen that these figures give only a general indication of the total manhours for the various categories of operatives.

Trades	Manhours
General Labourers	15,900
Carpenters	15,800
Steel Reinforcement Workers	5,300
Specialist Concretors (foundations 1,700 (superstructure 1,080 (floors <u>1,220</u>	4,000
Drivers and Plant Electricians	3,500
Total Manhours -	<u>44,500</u>

Taking the figure of 1,080 manhours for specialist concretors on the superstructure and adding to it a similar number of manhours for mechanical plant operators this produces a total of 2,160 manhours. Then we have to assume what manhours were expended by the general labourers on the superstructure. A ratio of 1:1 as between specialist concretors and labourers has been suggested but I consider that this errs on the side of the specialist concretors. Surely the ratio would be at least one specialist to two labourers, probably 1:3.

Assuming it to be 1:2, the total manhours spent on the superstructure would be roughly as follows:-

Specialist concretors -	1,080
Labourers -	2,160
* Plant operators -	<u>630</u>
	<u>3,870</u>

Assuming/

* Assuming further that two-thirds of the plant operators' time was employed on concreting the number of manhours spent on the superstructure would be :-

$$\text{Two thirds of } 3,500 \times \frac{1,080}{4,000} = 630.$$

Thus we have a total of 3,870 manhours employed on the concrete walling and according to the contractor's figures there were 1,050 cubic yards of concrete used in the walls together with the facing blocks. Allowing, say, 870 manhours for fixing the facing blocks then 3,000 manhours were taken up in placing 1,050 cubic yards of concrete and the final approximation is three manhours to one cubic yard of concrete. This is fairly excessive, even when the various factors of thin high walling, initial slowness in grasping a new technique of shuttering, etc., are considered. However, had progress not have been held up by frost then it is practically certain that the building would have been handed over many weeks before a similar building, based on orthodox methods of construction could have been. With such an early handover there would have been an immediate cash return in rentals, and this gain in rent could quite easily have offset the additional cost of labour on a fast concreting technique.

It was indeed unfortunate that this remarkable achievement was not costed more accurately so that the climbing/

climbing shuttering technique could be more widely adopted by contractors with complete confidence in the final economic result, through the ability to complete poured concrete walling in less time than ever before. The client must play his part in encouraging the contractor to use more expensive methods in the interests of speed; he must either see that a penalty, commensurate with the amount of rents lost, is imposed on the contractor who is not prepared to organise and equip himself for fast building or he must reward the contractor who gives completion before time. I know of one small local authority in Midlothian that does both of these things - the contractor who finishes and hands over a house one week or more before the official contract date receives the equivalent of a week's rent on that house for every week. On the other hand, if he is behind time in handing over, he is penalised on the same scale.

Among the many special forms of shuttering is the type which involves small hand-portable sections of steel shuttering into which a semi-dry concrete mix is placed. ⁽⁶⁸⁾ The shuttering sits in position on the wall which is being constructed and is of such size and weight that it can be easily moved to a fresh position by one man. Sufficient cohesion and stability in the semi-dry concrete can be achieved/

achieved by tamping so that the form may be moved to its next working position immediately after filling. It is claimed that the whole cycle of operations for a length of 22 inches of wall, 9 inches deep and 11 inches thick, takes about $2\frac{1}{4}$ minutes, which amounts to a speed equivalent to about 2,000 to 2,800 bricks laid per day for the same amount of paid labour. This may well be, but the claim does not appear to me to take full account of time lost at angles, openings, return walls, etc.

Given suitable conditions, there is I think, a limited use for this form of portable shuttering. First there must be no angles other than right-angles because special forms are not usually available for other degrees of angles. The building plan must be extremely simple and door and window openings should be designed with reference to a module to suit the shuttering sizes. The external and internal wall finishes from the shuttering appear to me to be rather more irregular than brickwork and this would mean increased plaster thicknesses. The use of the portable shuttering involves a technique that would not be quite so easily learned as the makers claim, for the plumbing and alignment of the forms appears to me to demand considerable care and skill, particularly the alignment between angles.

Such/

Such a technique is ideally suited to one or two-storey houses in remote areas where bricks have to be transported long distances and where there is an abundant supply of suitable concreting aggregates. These conditions occur frequently in the Highlands and Islands of Scotland and it might be a very good thing if, after adequate trials, the Department of Health or Agriculture could recommend the technique to small contractors in these outlying areas.

As an alternative to wood and metal shuttering of orthodox design, resin bonded plywood is being made up as a permanent shuttering but so far its use has been confined to flooring. Other forms of permanent shuttering for poured concrete walling have been extensively used - gypsum plaster precast units, precast concrete blocks, terra cotta facing blocks, etc., the main object being to provide a finished wall surface on one or both sides of the wall and to save the cost of temporary shuttering at the same time. There is little doubt that shuttering is responsible for a substantial part of the cost of any poured concrete walling and greater attention should be paid to the development of formwork that is more adaptable to different wall sizes. The waste of manhours and material on shuttering is evident on almost every site where concrete is placed in situ and every floor is littered with pieces of unusable timber.

Reinforced concrete has been freely used as a walling material for over fifty years; usually the concrete has been covered with rendering because the early methods of "insitu" concreting left unsightly form marks and porous surfaces. During the past twenty years or so, examples of exposed concrete as left by the shuttering, or aggregate exposed by mechanical scraping have become more numerous.

An examination of many reinforced concrete buildings erected during the past fifty years ⁽⁶⁷⁾ has indicated a certain amount of deterioration, spalling, staining, cracking, etc., suggesting that there is a need for a ^{higher} standard of design and workmanship if reinforced concrete walls are to be relied upon to have a trouble free life of more than twenty five years or so. Almost all concrete is porous to some degree and consequently can become saturated with water; the expansion of this water when frozen leads to the formation of cracks and the ultimate disintegration of the concrete. Spalling or splitting of concrete occurs when reinforcement corrodes through the penetration of moisture which flows down the reinforcement and sets up a leaching effect that reduces the alkaline protection of the concrete and allows corrosion to take place.

Cracks in concrete may occur through a variety of causes/

causes, such as shrinkage or bending stresses, faulty construction joints, insufficient consolidation, moisture and temperature movements, etc., Insufficient cover of concrete over reinforcement is also responsible for failure of concrete in many instances.

To prevent these faults and failures occurring in reinforced concrete walling it is obvious that saturation of the concrete must be avoided by the use of protective renderings together with the careful design of all projections, sills, copings and the like, to ensure that water cannot collect and concentrate. The need for adequate cover over reinforcement must be fully appreciated and understood by everyone - not merely the designer. The workman who places the reinforcement seldom realises the importance of his work, and this ignorance could be removed in some part by a series of explanatory talks conducted on site by the engineer at an early stage in the construction.

Some causes of failure such as moisture or thermal movements may be inherent in the design and it is up to the structural engineer to remove these. If a foundation is rigidly fixed, then the expansion and contraction of floors will cause considerable stresses to be set up at the end columns in long buildings and cracks may appear adjacent to these/

these columns, particularly in panels between stanchions and at the head and cill of window openings. This has occurred frequently in reinforced concrete walling erected in this country and the lesson to be learnt from this is that much more consideration must be given to this vital problem of thermal and moisture movement than has been given hitherto.

Many architects and engineers are urging that all reinforcement in external walls should have a minimum cover of $1\frac{1}{2}$ in. and I agree with them, but I would go farther and insist that all the important processes in concreting such as bar bending, shuttering, mixing and placing, should be carried out by qualified concretors and not ignorant labourers. Courses in concrete technology for site workers are available at technical or art colleges in most large towns and the City and Guilds of London Institute holds annual examinations in Concrete Technology for which a Certificate of Competence is awarded to successful candidates. In Edinburgh, a capital city with a population of half a million, the entry of students for this course averages about ten or twelve a year, and most of these come along on their own without the knowledge or encouragement of the employer. Not all employers are in favour of another skilled grade in the hierarchy of tradesmen, and their reasons are not hard to discern. Yet how can we expect to see reinforced concrete buildings of unvarying high quality and durability if workers are not trained to the work?

Curtain Walls.

Architects have for a long time been faced with the problem of forming the external walls to framed buildings ^{is} where there/ ~~no~~ need for anything but an infilling or curtain between the structural skeleton of the building. The first choice is often cavity brickwork because it performs nearly all the functions required of an external wall - thermal insulation, weather resistance, stability and appearance - all at reasonable cost. Such a wall is not, strictly speaking, a curtain wall for it contributes considerably towards the stability of the structure, chiefly through a lateral bracing action between the framework, therefore the following observations and criticisms will be confined as far as possible to curtain walls which have only to keep out wind and weather.

A great deal of progress has been made in the development of curtain wall construction in America, though there have been a few setbacks, but much more needs to be done in this country so that the availability of more information on the behaviour of different types of walling and standard interpretations of byelaws may give the architect greater confidence to try out new materials and techniques.

Curtain walling must be fire and weather resistant, durable/

durable and pleasing in appearance. It must have sufficient stiffness or stability in itself to resist stresses set up by wind and lastly it must be reasonable in initial fixing cost. The requirement for weather resistance includes satisfactory behaviour as regards moisture and thermal movement in addition to moisture penetration either direct or through capillary action, and it is of particular importance to note that many instances of costly failures of curtain walls have been due to moisture or thermal movement.

There is a wide choice of materials for curtain walls, they can be in some form of metal sheeting, plastic, glass, wood, asbestos, concrete or clay product. Aluminium meets most of the requirements already mentioned for curtain walling; it is a light material, well adapted to extrusions conforming to any design. Aluminium has a natural resistance to corrosion and its appearance is reasonably good. So far in the United States some thirty ^{large} buildings have aluminium curtain walls and many more are in progress. Generally the material is about one eighth of an inch thick and is produced in ribbed panels giving increased stiffness.

A prefabricated curtain wall panel consisting of a veneer of 26 gauge embossed aluminium on a backing of asbestos insulation board has been produced in this country by a firm specialising in the manufacture of asbestos board. (70)

The/

The panels are meant to be used in conjunction with an inorganic mat infill and an internal facing sheet. The embossed aluminium outer veneer is textured to represent a stucco pattern and its appearance is quite pleasing. Unfortunately only the standard grey aluminium self colour is available - this is a drawback which is common to most forms of aluminium sheeting. Some of the aluminium faced schools in this country have been coated with a special paint but it does seem wrong to be forced to apply a paint to material which is, in itself, resistant to corrosion. American manufacturers claim that anodising can produce a range of durable colours in aluminium panels used as external curtain walling and it will be interesting to see how existing buildings faced with these coloured panels stand up to long term exposure. The high cost of colour anodising linked with the expense of the aluminium sheet itself is bound to discourage the architect in this country from experimenting and it may well be that the lower cost of enamelled steel as a facing material will eventually rule aluminium out as an expensive luxury.

(71)

The technique of using enamelled steel plates for external surfaces of buildings is quite a recent development and yet vitreous enamelled sheets for advertisement hoardings/

hoardings, refrigerators, washing machines, kitchen table tops, etc., have been manufactured for many years and one is tempted to ask why someone did not think of using this material in buildings before. Many a gable wall of an old building has been protected for thirty or forty years by large enamelled steel sheets advertising the products of old established firms and apart from an occasional rusting at the edges these advertisement panels appear to have weathered remarkably well.

It is essential, of course, to distinguish between vitreous enamelling and stove enamelling when considering the suitability of enamelled steel sheets for surfacing buildings. Vitreous enamel is virtually a glass surface applied to steel sheet and if kept free of mechanical damage its life is unlimited. Large advertising firms have assured me that they have vitreous enamelled steel signs which have been exposed for forty years without any sign of breakdown. At the same time it is interesting to note that the Ministry of Transport has prohibited the use of vitreous enamelled steel road signs on account of the risk of deterioration through mechanical damage. So it seems quite clear that if this material is to be used in buildings, then it must be regarded simply as glass and every precaution taken to protect it from damage which might result from moisture or thermal/

thermal movement.

Stove enamelled panels are made of soft steel sheets which are specially treated after rolling so that they are completely smooth in order to take the enamel. A primer or basic coating of enamel is first applied to both sides of the sheet, then the finishing coat of the desired colour is applied and finally the sheets are fired until the enamel melts at a temperature of ~~400~~ 100 to ~~400~~ 300 degrees Centigrade and is fused into the metal surface with a resultant hard glossy finish which has a high resistance to wear and impact.

Increasing use of these enamelled sheets as a facing material is being made in Danish construction, ⁽⁷²⁾ the largest plates produced are approximately 3 ft. by 6 ft. but those in common use average about 21 in. by 28 in. and weigh about thirty pounds to the square yard. The edges of the plates are turned back at a right angle for several inches to ensure stiffness in the individual plate and to facilitate fixing.

In my view, the essential thing to remember is that steel is a material that expands and contracts when subjected to varying temperatures, and it will rust and deteriorate rapidly at any point where moisture is permitted to penetrate to the unprotected steel sheet. Condensation is ^{also} almost certain to occur behind the sheets. It follows then, that the protective enamel covering must be unquestionably durable for the life of the building. Also that the jointing must allow for thermal movement, and some provision must be made to drain away water deposited behind the panels through condensation.

Glass has many attractions as a curtain walling material. It is light in weight, low in maintenance cost and will remain clean in the atmosphere of an industrial town. But since glass is a non-absorbent material it demands a high standard of weather resistance at all joints. The expansion and contraction of glass under varying temperatures can be quite considerable, particularly in coloured and obscure material, and the brittle nature of glass demands adequate glazing tolerances. This means that the joints must be of such a form or composed of such a material that water penetration is impossible and yet, at the same time, the joint must permit thermal movement quite freely.

The various putties in present day use are seldom durable over long periods and mastics are inclined to lose their plastic qualities after long exposure. A form of rubber jointing similar to that used in car. window construction has been tried out in America but what constitutes a success over the comparatively short life of a motor car may not necessarily be suitable for severe exposure in a high building over 25 to 50 years.

The patent glazing bar has much to recommend it for it is designed on the sound principle of permitting the glass to move within the joint and the provision of drainage/

drainage ducts for any moisture that finds its way into the joint. This is far better than attempting to devise a joint that will seal up the gap between two panels and maintain that seal while the panels lengthen and shorten according to the prevailing temperature.

Curtain wall glazing has been employed on a number of schools in the London area and appears to have been quite successful from the point of view of weather resistance. Patent glazing was used in each case and the curtain wall was continuous over a light steel frame. The fact that this type of material has been used on several schools suggests that its cost compares well with other curtain wall materials. The Ministry of Education target figures for school construction are too rigid to permit wild and wasteful experiment and according to the cost analysis of the county secondary school at Catford the unit cost for glass curtain walling was quite reasonable when due allowance was made for the fact that such walling combines its own finish and decoration, inside and out.

There are two important criticisms of the use of large areas of glass in the external covering to buildings - first, unless the technique of double glazing is adopted there is bound to be a serious deficiency in the thermal insulation of/

of the building, and second, there may be considerable fire risks where large walls of glass are liable to collapse completely at a very early stage in any major fire.

The answer to these criticisms, I feel, can only be found in some form of composite section of glass-sheathed panel that will combine thermal insulation with fire resistance. New types of glass are being developed in this country, experiments are being made with stove enamelled glass in permanent colours. Meanwhile the constant observation of existing glass covered buildings such as the Lever Building⁽⁷⁴⁾ and the United Nations Building is helping to build up a stock of valuable data that will help to establish glass as a reliable walling material.

Asbestos fibre was bonded with ordinary cement to produce a building board more than forty years ago and since then it has been developed considerably as a cheap light material which is resistant to corrosion and can be manufactured in flat or corrugated section or in practically any other type of section suitable for sheets, pipes, gutters, etc. As a building material it has suffered from a certain stigma due perhaps to its association with buildings of a temporary character such as the huts that were erected shortly after the 1914/18 War and again the "prefabs" that were built after the/

the last world war. When asbestos-cement roofing tiles were first produced the majority of building contractors distrusted them and although there exists today an extremely comprehensive range of asbestos-cement products their use still tends to be confined to small commercial buildings and low-cost housing work.

Perhaps also the monotonous grey colour and brittle nature of this material has much to do with this lack of acceptance together with the tendency of earlier examples of asbestos-cement products to deteriorate with age or to undergo a structural breakdown when saturated. ~~without~~ The brittleness of the material certainly is a major defect, particularly when used on roofs when special safety measures need to be taken. Recent developments however, have been made in connection with the bonding of asbestos fibre with other forms of silica rather than with cement and the result appears to be that an entirely new form of material has been produced with marked advantages over the original product.

A permanent inorganic bond is obtained in the new material by subjecting it to high pressure steam curing. It is claimed that the new asbestos fibre board has almost doubled in impact resistance and bending modulus; resistance to fire has been increased together with resistance to thermal losses. Other developments include panels of asbestos/

asbestos board pre- decorated with a two-coat external stucco finish and sandwich sections composed of stove enamelled asbestos board behind an external skin of plate glass, or a vitreous enamelled steel outer unit with an interior facing of asbestos board and a core filling of insulation slab.

These are important developments in a material that has changed so very little since it was first produced. If the cost can be kept down there may be quite a future for this material in curtain walling or in partition or internal walls.

The technique of cross wall construction, whether applied to large multi-storey buildings or to two-storey houses, goes hand in hand with curtain walling . Low-cost two-storey houses at Canterbury combined loadbearing cross walls of brickwork with front and rear curtain walls consisting of timber framing covered externally with felt, one inch wood wool slabs were then built in front of the felt covered framing and the final external finish was two-coat rendering on wire netting fixed to the wood wool slabs. The internal face of the wall was made up in lightly skimmed plasterboard backed up with aluminium foil.

This was a wall that was designed primarily to reduce/

reduce cost and since the houses were built for £1,000 each it seems evident that substantial economies were made somewhere, for these experimental houses were three-bedroom four person type and are in accordance with the requirements of the Ministry of Housing and Local Government. In the final analysis it was estimated that these houses were built for less money than comparable two - bedroomed houses had been built for in the same district. The average saving was £64 per house and the technique of curtain wall construction contributed largely towards this. At the same time the form of walling was in no way inferior to ordinary brick construction - the wood wool slabs and aluminium foil provided a degree of thermal insulation at least equal to that of an eleven inch brick cavity wall.

I have seen walling of this type erected in the Midlands some twenty five years ago, a timber framing was covered with felt and two coats of rendering applied to expanded metal mesh fixed to the timber framing. There were no wood wool slabs or aluminium foil and the inner surface was made up of ordinary lath and plaster on the timber framing. The houses have weathered well for these twenty five years ~~and~~ although the thermal insulation would have been vastly improved if some filler or quilting had been introduced into the/ wall.

A new method of constructing an infilling or curtain wall between crosswalls to low-cost two-storey houses has been recently tried out in England. ⁽⁷⁵⁾ The wall can briefly be described as a sandwich wall built "in situ"; first wooden frames or profiles corresponding to the size of the external opening between crosswalls, ground floor slab and roof wallplate are made up. To these frames are bolted the various doors and windows for both storeys, then the entire frame is placed in position on the foundation slab, plumbed and temporarily stayed in position. These frames then act as plumbing profiles for the bricklayers building the crosswalls.

When the roof is on, the front and rear wall panels are infilled by "in situ" sandwich walling which consists of a central core of $2\frac{1}{2}$ in. cemented woodwool slabs. The slabs are lined in position on both sides by using light-gauge reinforcing wire stretched between the wooden framing. Then the reinforcement is fastened to the woodwool slabs by staples and the whole consolidated into a rigid panel by normal plastering to the wire reinforcement and woodwool slab on the inside and cement rendering with spatterdash finish against the wire reinforcement and woodwool slab on the outer face.

An/

An alternative wall providing increased weather protection was the subject of further experiment and consisted of a $1\frac{1}{4}$ in. woodwool slab with reinforcement as described, plastered $\frac{1}{2}$ in. thickness both sides and then provided with an outer skin made up from 2 in. by $1\frac{1}{2}$ in. studding covered with $7/8$ in. thick weatherboard.

The quantity surveyors for this contract had access to the contractor's actual net costs for labour and materials and it was estimated that the saving per house resulting from the employment of a sandwich wall as described, but without the weatherboard cladding, was £49. The use of the additional cladding reduced the net saving on the non-load bearing external walls to £35. Internal partitions were constructed as described for the first method and the saving here was estimated to be £8 per house.

The first walling method, of plastered and rendered woodwool slabs appears to me to be rather flimsy and I doubt very much the capacity of such a wall to absorb moisture from continuous rain for an appreciable length of time. Too much dependence is placed upon the external rendering and I would prefer to see a cavity or an impervious lining of some sort behind the woodwool slab, acting as a barrier to moisture penetration.

An extremely simple system of wall construction has been designed for terraced two-storey houses at Hatfield New Town. The amount of brickwork in the houses has been (76) reduced to a bare minimum and consists only of a 9 in. party wall and one chimney breast on the ground floor reducing to an 18 in. square stack at upper floor level. Cross bracing is secured by a prestressed concrete beam spanning the 9 in. party walls front and back; these beams also support the first floor joists and the light loadings imposed by external panel walls.

One of the outstanding points of interest in this method of construction was the completion of the roof structure and covering as soon as the brick party walls and chimney stack were completed. This was achieved by supporting light trusses on the party walls and covering in the roof with nineteen asbestos cement sheets continuous from ridge to gutter. This method of roof construction resulted in a series of gables with attractively painted barge-boards on the front elevation providing a welcome change from the usual terraced elevation.

Immediately the roof was completed, practically all the remaining operations were carried out under cover. The external spaces between crosswalls were filled in with 3 in. by 2 in. timber studding faced in red cedar and lined with a one/

one inch thickness of woodwool finished with a five eighths thickness of plaster.

It was unfortunate that the external panels were not prefabricated, for the simple walling technique provided every opportunity for this. However the reduction of the brickwork to such a small quantity, the use of the modern technique of prestressing in the wide span beams and the provision of a covering over the work at such an early stage - these are all points that deserve favourable mention. Perhaps some criticism could be made of the use of a 9 in. solid wall as a party wall, also the central gutters between adjacent roofs are not ideal from the point of view of good maintenance-free construction. But it must be admitted that this form of drainage dispenses with the necessity for expensive and unsightly fall pipes on the front elevation of the houses.

These houses were put out to tender along with other types of traditional design and one can excuse the architects for wishfully thinking that the tendering contractors would recognise the economic possibilities in a design that reduced brickwork to a minimum and embraced an extremely simple roof construction at such an early stage in erection proceedings. Unfortunately the tenders were no lower than those for traditional construction and whatever saving there was went into the contractor's pocket.

(This form of roofing has been used successfully at Glenrothes New Town, Fife.)

WALLS OF STRUCTURAL GYPSUM PLASTER.

Large prefabricated wall units in small one and two-storey houses have been produced in many forms embracing almost every material and every conceivable size, shape and section, and it would hardly be possible within the scope of this thesis to examine more than a few of the more interesting techniques which have recently been developed.

Wall panels of gypsum have recently been developed and produced on a commercial scale in Scotland. The storey-height panels consist of two outside sheets of reinforced plaster bonded to a reinforced plaster core of honeycombed section; the panels are loadbearing, about 2 ft. 6 in. wide and the thickness varies according to the load to be supported.

The edges of the panels are grooved and the walls are formed by temporarily clamping the panel units together and pouring liquid plaster into the cavity formed at the edges by the meeting of the two grooves. The plaster sets quickly, bonding the wall units together so that the finished wall can be regarded as practically monolithic.

(77)

Building Research Station tests have been made of the strength of four inch walling constructed with these gypsum units and the ultimate failing load averaged out at 4.5 tons per ft.run. A second wall was tested, but with cement-mortar joints instead of plaster, and the failing load for this was 6.6 tons per/

per ft. run. The weight of this gypsum panel walling works out at about nine pounds per sq. ft. which is less than a quarter of the weight of comparable walling in brickwork or concrete. The thermal insulation value also compares very favourably against normal eleven inch cavity brickwork.

Other advantages of this new prefabricated walling material include fire resistance of a high degree and an absence of thermal movement under normal temperature changes. Electric conduit, piping etc., may be housed in the panel cavity or can be cast in, and the gypsum plaster can readily be sawn, drilled or even planed.

The main criticism I have to make in connection with this material centres on the inherent weakness of gypsum plaster when it is wet. Sustained moisture will cause it to deteriorate in strength and there may also be unsightly staining of wall surfaces. I doubt also whether any Scottish authority is likely to permit water pipes to be imbedded in this gypsum walling for I feel that there is a distinct danger of corrosion. Panels of this material are probably excellently suited to one-storey buildings with a generous roof overhang or some similar means of keeping the walls dry. Wide use has been made in Australia ⁽⁷⁸⁾ of this plaster walling where loadbearing walls $2\frac{1}{2}$ in. thick have been reinforced/

reinforced with a welded wire mesh, but most of the Australian buildings are of the bungalow type and are usually faced up with a brick veneer. The Australian technique of house-building incorporating prefabricated gypsum plaster walling follows the normal construction method for that country in which the inner walls are first framed up in timber, the roof put on, the walls lined and the house occupied, probably months or years before the single brick outer wall is built around the house. Prefabricated plaster walls take the place of timber-framed inner walls, the wall units being produced in a factory situated close to the site where the raw gypsum is quarried.

(79)

Another Australian development of structural plaster is the manufacture of four complete walls and ceiling poured in one unit. These plaster cells or boxes are factory produced in two standard sizes 8 ft. 9 in. by 12 ft. 6 in. and 8 ft. 9 in. by 5 ft. 0 in, and variety in house layouts is obtained by many ingenious arrangements of these two room sizes to form complete houses and other types of buildings besides. Where two cells adjoin there is necessarily a double wall and advantage is taken of the cavity between these walls to accommodate pipes and services.

The main difference between the Scottish and Australian/

Australian systems is that the Australian gypsum plaster wall is intended to perform the function of an inner wall only while the Scottish walling is meant to act as an outer wall, lining or partition wall. Also, the Australian plaster walling is usually a large thin wall of solid section, reinforced with light welded wire or plaster-soaked Sisal fibre, while the Scottish unit is much smaller in width, honeycombed in section, un-reinforced but of greater wall thickness.

Comparative costs for Australian construction have been worked out by the News and Information Bureau of the Australian Department of the Interior, ⁽⁷⁸⁾ and these costs show that a typical villa of 1,300 ft.super costs £A4,525 in brick cavity construction, £A3,500 in single brick wall facing on timber inner wall, £A3,075 in timber throughout and £A2,900 for structural plaster inner walling with single brick facing.

These costs certainly make out a case for gypsum plaster walling in Australia. But ordinary brick walling is very expensive there, much more so than in this country, and it is consequently out of the question to relate this cost example to conditions in Britain. Early in 1955 the Basingstoke local authority built a number of two-bedroomed houses/

houses incorporating cast plaster panels for loadbearing inner walls. These houses, with a total area of 740 sq. ft. cost £1,132 plus £105 for external works. At this price for small two-bedroomed houses there would appear to be little saving through using gypsum plaster panels, but the houses were completed far more quickly than they would have been had they depended on a traditional plastering finish; for at that particular period there was a most acute shortage of plasterers in the locality.

The Bailey Report on the Quicker Completion of House Interiors⁽⁸⁰⁾ commented very favourably on the gypsum plaster wall and considered this new technique to be most promising. In Appendix C of the Report it was estimated that this cast walling could be erected for approximately half the manhours taken to build brick walling, but the cost ratio indicated that the gypsum walling was still rather more expensive than the standard brickwork.

It has been claimed that gypsum panel walling may revolutionise house-building all over the world. Already, negotiations have been concluded for the setting up throughout Canada, of fifteen plants under the Scottish firm's patent. Canadian labour is to be trained in the technique and thereafter, Canadian firms will manufacture the gypsum and will build houses themselves. Licences for this patent walling/

walling have also been taken up in Germany, France, Egypt, Sudan, Iraq, Tanganyika and Nyasaland and negotiations are proceeding for the use of the walling in India, Ceylon, Rhodesia, New Zealand and Australia. So far as Britain is concerned the patentees claim that ten per cent could be saved on a house now costing £2500 but I am of the opinion that this claim is based on hypothetical circumstances, not so far experienced, where a very large number of houses is erected close to the factory, and moreover, where those houses are specially designed for gypsum walling in accordance with a suitable module.

It seems to me that this method of prefabricated structural plaster units places too much reliance on the mass production of the units in a factory which may be remote from the building site and it would be interesting to develop a technique by which interior plaster walls could be prefabricated on the building site in standardised steel moulds. Given a suitable quality of sand I consider that a mixture of pure gypsum plaster and sand, together with very light wire reinforcement could be used to prefabricate internal walling on site. The panels would have to be cast with solid sections about $2\frac{1}{2}$ inches in thickness or maybe as little as 2 inches, for the risk of damage in transit would be/

be removed and the technique already described, of raising the wall and its shuttering to a vertical position before lifting into position could be practised. The plaster could be transported in bags to the site, as it already is for normal plastering, and the prefabricated wall sections could always be cast under a rough shelter during wet weather if necessary. The setting time for plaster is so short - only about an hour's delay before removal from the mould is possible - this means that the number of moulds on the job can be reduced to an economic minimum.

There are, I consider, attractive possibilities for the use of structural plaster in loadbearing internal walls and partitions but until existing buildings employing this technique have had opportunity to weather for a year or so and have yielded more reliable data than is available at present, I would hesitate to recommend unprotected gypsum plaster for use in external loadbearing walls. There is little doubt that the gypsum house can provide an answer to the problem of housing populations in under-developed areas such as in South Africa where native populations are being housed in tents which cost about £40 each and have a limited life, but for competitive house-building in this country I am convinced that factory costs must be considerably reduced before the technique is widely adopted.

* The Scottish Bellrock Company have produced a patent finish for their external wall units which is claimed to be weather resistant.

Useful cost and construction information in connection with structural plaster walling has recently been made available through a War Office experiment⁽⁸¹⁾ in building twenty Soldiers' Married Quarters in this country. the intention was to evolve a building technique that could be adapted on the site under primitive overseas conditions wherever local supplies of gypsum could be made available.

In the method adopted, large gypsum plaster panels 11 ft. 8 in. by 8 ft. were prefabricated in a factory on the building site. Every effort was made to simplify the casting process so that the panels could be made by unskilled labour without any special training. The moulds consisted simply of a light wooden frame clamped to a table faced in smooth aluminium sheet. When the plaster is poured into the mould a second mould is pressed into the face of the plaster while it is still wet; this produces a coffered or indented pattern on the inside of the plaster slab.

After hardening the panels are erected on a normal foundation base so that they form a permanent inner shuttering for an outer walling of no-fines concrete. The shuttering for the outer face of this wall is made up in expanded metal stretched over a timber framework, similar to the shuttering usually employed on no-fines concrete construction/

construction.

The twenty houses were erected in two operations. The first ten houses encountered the usual difficulties associated with the employment of new methods of construction for the first time. When these difficulties had been overcome and workmen were more experienced the second batch of ten houses was put in hand and costs separately kept for them. The total cost for the second group of ten houses worked out at £18,408, and for houses having a floor area of only 940 ft. super this was not very encouraging from the economic standpoint. However, it was anticipated that an appreciable saving would be made on a larger number of houses, particularly when complete familiarity with the new technique of erection had been established.

The cost of the site factory, casting table, etc., sufficient for the twenty houses together with mechanical handling plant was £4,200 and it was estimated that a larger installation capable of prefabricating panels economically for a £1m. contract would cost about £20,000. For the average sized contractor in this country, who might already possess some mechanical plant, the initial cost of a suitable site factory should not exceed £5000 or so, and assuming a saving of only £50 on each house this capital cost should soon be recouped.

Partition Walls.

During the inter-war years partition walling in house construction was confined mainly to plastered brick, clinker blocks, or timber studding with a plaster or board finish. In office buildings, lighter and thinner partitions with glazed panels have been used for some time but not many of these have combined a particularly high degree of sound insulation and fire resistance.

Dry, light construction is undoubtedly an asset in any technique of partitioning, particularly if coupled with standardisation of unit sizes so that the walls may be capable of rearrangement and can thus ensure a really flexible plan. It is exceedingly difficult to achieve efficient sound insulation between one room and another with a dry partition which is simply screwed or bolted into position. One has only to try the experiment of building a 3 in. clinker block wall separating two rooms and observing the degree of sound insulation before and after plastering. The difference after plastering is remarkable, and seems to be due to the sealing effect of the plaster rather than the thickness of it, for a similar effect is noted when a plaster-boarded partition is coated with a plaster skim.

A 2 in. thickness of compressed strawboard has
a/

a fair resistance to sound transmission and sheets of this material can be obtained in 8 ft. to 12 ft. lengths with a standard width of 4 ft. The problem here is the treatment of the vertical joints between the sheets so that a flush surface is obtained together with unimpaired insulation.

Partition wall panels of this type have been widely used in Sweden ⁽⁸²⁾ and are available in this country. The units are made up from a central core of compressed straw enclosed between two hardboard sheets giving a total thickness of 2 in. The edges are framed in timber and strips of felt are inserted at all joints to ensure efficient soundproofing. The "U" value claimed for these units is .37 and the sound insulation factor is 34 decibels. Perhaps the most interesting and useful point about this form of partitioning is that it can be obtained in four basic units—one plain standard unit, one incorporating a door, one with a cupboard door and a special narrow unit meant for filling in the depth of cupboards, etc.

This form of partitioning provides maximum flexibility of plan, for it can readily be demounted and fixed in a different place. My main criticism of the system is that, like most prefabricated units the joint cannot effectively/

effectively be concealed and it is necessary to use cover strip of some kind. This I feel imposes restrictions on the decorative treatment of any room.

The structural gypsum plaster wall already mentioned under external walling is, I consider, one of the most suitable forms of quickly erected ^{partition}/walling, combining good sound and thermal insulation with fire resistance and an excellent wall finish. ⁽⁸³⁾ It does involve one wet process in the grouting to the joints but this is a fairly small operation compared with the area of the finished prefabricated walling.

In nine pairs of houses recently completed in England this method of prefabricated gypsum plaster partitions, party walls and interior loadbearing walls was adopted. The party wall was made up of two skins of structural plaster wall with slag wool filling and where the walls were required to be loadbearing, point loads were avoided by the distribution of stresses through timber or steel angle plates. All the interior walling was erected before the outer brick skin was built and the tie between the brick wall and the inner plaster wall was simply effected by ~~4~~ punching a hole in the back of the honeycombed plaster panel, inserting an ordinary cavity tie and making good with cement mortar.

Light prefabricated partitions, provided they have good sound insulation values and are sufficiently mass-produced as to be reasonable in cost, should compete successfully against permanent partition walls incorporating wet processes. They economise in erection time and there is no waiting for wet processes to dry out. In addition to this the flexibility of plan form which is made possible by demountable partition walls must inevitably reduce space requirements because the varying needs of this family or that can so often be met by a simple adjustment of the partitions. By so doing, space is being made more valuable and so, indirectly, this method of partitioning is another means of reducing building costs.

Where partitions are moved about on hollow joisted floors there will always be difficulty with sound insulation, for sound will be "structure borne" via the joists and floor covering. The same difficulty may be present of course in the case of a partition in a permanent position, particularly in light clinker block partitions on upper floors. However, it may be considered worth while to sacrifice a little in sound insulation in order to secure the advantages of flexible planning through movable partitions.

Workability Aids for Mortars.

Workability aids or plasticisers for mortars are quite a recent development in this country, but they have been used in the United States for rather more than ten (84) years. Mortar compositions for brickwork should be such that they attain a strength which is less than that of the brick so that any cracking due to thermal or moisture movement is localised in the joints of the brickwork rather than in the brick itself. Following this requirement the contractor must^{use}/weak or lean mixes with a high sand content giving a poor standard of workability. This lowers the rate of production and in turn, encourages the man on the site to add more cement or lime to the mix or to use a loamy and unsuitable sand in his efforts to satisfy the bricklayers' demand for workability.

The plasticisers in use today are mostly in a liquid form and are added to the mixing water. The action is physical, having the effect of entraining about 10% more air into the mix than is usual. The air, in the form of minute bubbles reduces the internal friction within the mortar, thus improving the workability and making it possible to use quite lean mixes.

A further advantage resulting from the use of plasticisers is that the air bubbles trapped in the mortar/

mortar cause the mortar to have a permanent molecular structure providing additional thermal insulation and a greater facility for any subsequent movement within the mortar bed.

(88)
Manufacturers of these mortar additives claim a saving of £4.10.0 per house where a good mortar plasticiser is used. This figure is based on a typical three-bedroomed house of approximately 1000 ft. super, normally using about $2\frac{1}{2}$ cubic yards of hydrated lime along with the total quantity of cement and sand used to make up the mortar for the brickwork. The cost of the lime saved is reckoned to be about £5. 10.0. and at the rate of approximately a half pint of plasticiser per cwt, of cement the total amount of plasticiser required would be $2\frac{1}{2}$ gallons costing under £1.

* I have experimented with one of the proprietary brands of plasticiser and can confirm that a lean mix of 1:6 cement and sand mortar was vastly improved in workability when the mix included plasticiser. During this experiment it was found that the resultant mix had a tendency to "run" too readily during wet weather, and special care had to be taken with impervious types of facing/

* Test results are set out in following pages.

facing bricks to prevent staining from dripping joints. It may be, of course, that the proper proportion of plasticiser had in this case been exceeded, but I was left with the impression that a great deal will depend on the attitude of the practical bricklayer to this new technique designed to improve the workability of mortars. At this stage there seems also to be a need for large-scale experiment with mortar additives so that more convincing comparative data can be established.

In Western Germany and Russia, mechanical means of spreading mortar have been used on mass brick walling. The methods employed include pressure feeding through a spreader shaped something like the nozzle of a vacuum cleaner. There is also a form of "sledge" which slides along the wall and leaves a trail of mortar on the various divisions in hollow block or cavity walling. The sledge is fed by a an over-riding hopper fitting closely over the sledge.

Mechanical methods of bedding mortar are hardly applicable to wall construction in this country for there is very little mass walling used in housing work. Indeed there are probably very few bricklayers in Britain who have had the experience of working on a wall exceeding $13\frac{1}{2}$ in. in thickness.

Test Results on Mortar Plasticisers.

In this test 18 tensile briquettes and 18 compression cubes of cement and sand were cast in moulds of size and shape complying with B.S.12. Details of the sand/cement mix and test data are tabulated below:-

Mix A (6:1) 6 standard sand: 1 Portland cement, 10% water by weight containing 1 part of plasticiser to 360 parts of cement.

Mix B (Control specimens 6:1) as for Mix A but without plasticiser.

Mix C (8:1) 8 standard sand: 1 Portland cement, 10% water by weight containing 1 part of plasticiser to 360 parts of cement.

Mix D (Control specimens 8:1) As for Mix C but without plasticiser.

TEST RESULTS (lbs. per sq.in.)Mix A (6:1)

		<u>7 days</u>	<u>14 days</u>	<u>28 days</u>
Tensile Briquette No.	1	113		
	2	95		
	3		150	
	4		130	
	5			225
	6			150
		_____	_____	_____
Average tensile strength		104	140	187.5
		_____	_____	_____
Compression Cube No.	1	545		
	2	624		
	3		805	
	4		746	
	5			1042
	6			1175
		_____	_____	_____
Average compressive strength		584.5	775.5	1108.5
		_____	_____	_____

Mix B (Control Specimens 6:1)

Tensile briquette No.	7	100		
	8		113	
	9			168
Compression Cube	7	610		
	8		1145	
	9			926

Mix C/

<u>Mix C (8 : 1)</u>		<u>7 days</u>	<u>14 days</u>	<u>28 days</u>
Tensile Briquette No.	10	86		
	11	95		
	12		110	
	13		104	
	14			110
	15			130
Average tensile strength		90.5	107	120
Compression Cube No.	10	544		
	11	465		
	12		420	
	13		478	
	14			580
	15			725
Average compressive strength		504.5	449	652.5
<u>Mix D (control specimens 8 : 1)</u>				
Tensile Briquette No.	16	<u>90</u>		
	17		<u>106</u>	
	18			<u>90</u>
Compression Cube No.	16	<u>340</u>		
	17		<u>378</u>	
	18			<u>784</u>

NOTE - It was considered that it would be difficult to obtain significant test results for 3 day specimens of sand and cement at such low ratios as 6:1 and 8:1. In view of this the tests were made at 7 days, 14 days, and 28 days.

Wall Finishings

The most common internal finish for walling is conventional plaster, a wet and messy process which results in a clean, reasonably soundproof wall finish that it is considered cheap in comparison with a dry wallboard finish. Plastering consists of three basic processes - applying the plaster to the wall, levelling it, and smoothing it, and various attempts have been made from time to time to mechanise one or/other of these processes. A German method⁽⁸⁶⁾ recently developed, uses a machine for the first and last operations. The plaster is applied to the wall by a "flipper" acting centrifugally and projecting the plaster up to a distance of nine feet. The plaster is fed to the centrifugal projector by means of a worm screw device. The plaster is then levelled by hand in the usual way and finally it is smoothed by a light rotating steel plate, square in shape and actuated by a small portable motor carried on the back of the operator.

During tests carried out for the Institute for Building Research at Hanover,⁽⁸⁶⁾ it was established that the mechanisation of the first process achieved an increase in output of 47% and the smoothing machine was estimated to increase output by 10% to 20%. Altogether, taking into account the initial cost of the machine and running costs, it was calculated/

calculated that the cost of interior plastering could be reduced by as much as 30%. This technique of mechanised plastering was tried out in this country by Messrs. Wimpeys but I understand that the trial results were not impressive. In fact it was said by one site agent who saw the trial that most of the plaster was projected through the windows! This is probably another example of unenlightened exaggeration springing from a brief experience of a new and perhaps startling technique of spraying plaster on to the wall instead of the familiar traditional method of trowelling it on by hand.

In Russia, ⁽⁸⁷⁾ a technique of mechanised plastering has been developed in which the whole process is broken down into five separate operations and a specialist group of plasterers concentrate on each operation. The first group apply the plaster to the wall in two layers by means of a spray gun. The second group concentrate on the ceiling (presumably the fixing of insulation board), the third and fourth groups attend to angles, cornices, etc., and the fifth group follows up with the smoothing machine on the walls. This would seem to be very systematic and is clearly intended for very large schemes or otherwise the system would be liable to break down owing to overlapping of the five operations.

In this country the nearest approach to mechanised interior plastering is the spray gun ⁽⁸⁸⁾ method of applying coatings/

coatings of insulating plaster on to metal lathing. The material used in this patented process is a mix consisting of cement, exfoliated vermiculite, a lime plasticiser and water. Mechanised methods of applying external rendering have been used in this country for some years now, a hand-operated drum spinning a rubber "flipper" projects rendering on to a wall at a range of about 1 ft. to 2 ft. and produces a reasonably good texture which is called a "Tyrolean" finish. The spray gun has also been used for textured outside renderings.

In mechanised plastering there is usually the difficulty of feeding the machine continuously, particularly when the machine is carried around on the back of the operative. In this type of machine the combined weight of machine and plaster should not exceed 20 or 30 pounds and this restricts the capacity of the container so that valuable time is wasted in recharging it frequently. The German machine moves about on two wheels and a front bogey wheel, and can be refilled while plastering is going on. The combined weight of the mobile container and thrower is 275 lbs. and it can be wheeled through openings 2 ft.4 in. wide.

In the Hanover tests it was stated that the finish obtained by mechanical methods was in no way inferior to that obtained by traditional methods. ~~But it is well known that the~~
~~Standard~~

There have been some very interesting developments in exposed aggregate finishes applied to precast concrete slabs. In this technique of wall finishing the precast concrete slabs are made up from a selected aggregate that will give the required colour and texture when exposed. The method of exposing the aggregate may be by scraping, grinding, brushing or spraying with water at a suitable stage in the setting of the concrete. Natural grey cement may be combined quite satisfactorily with certain aggregates to produce a reasonably colourful panel. In this photograph Messrs. Laings have a number of test panels mounted outside their Research and Development Centre and some of these are made up from natural aggregates with ordinary grey cement. In most cases they are the darker panels - the browns and the greys; for the lighter shades it is more usual to employ a coloured cement because the grey cement tends to absorb so much of the lighter colours.



The/

The great advantage of using these prefabricated exposed aggregate panels is of course that the desired texture and colour can be more uniformly produced under workshop conditions than on the site. Again the panels can be built into a pleasing pattern, either with continuous vertical joints or as bonded slabs, and the joints may be emphasised to improve the pattern effect.

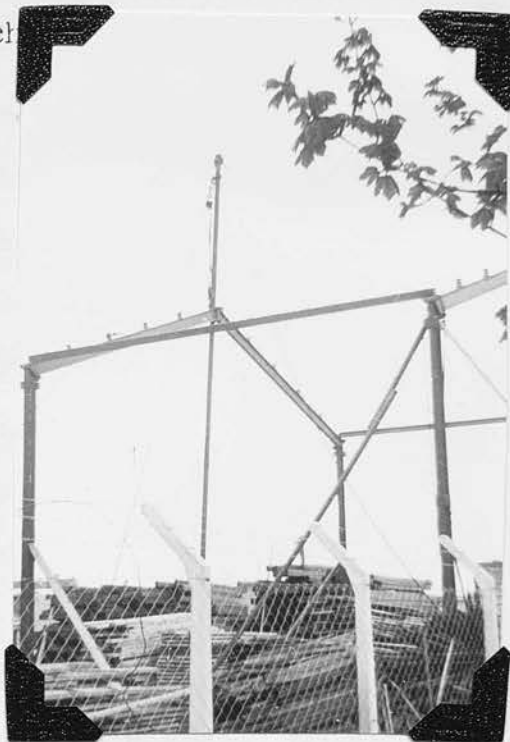
This photograph shows another test panel at Messrs. Laings' establishment. This is faced with quite large sized stones. Most of them are flints and are extremely hard but very colourful in a range of light and dark browns. The panel has been left in a horizontal position so that the effect of weathering will be much more severe than it would be on a vertical wall face.



In this instance the stones were placed on top of the panel while the concrete was wet, and then they were pressed in and lightly washed off with water just prior to setting.

Mechanical Hoisting Equipment in Wall Construction.

Twenty years ago it was quite usual to see bricks, mortar, heads, cills, window frames, flooring and roof components carried up to successive storeys by hods, headboards, and ladders, or possibly hauled up on the end of a rope with two or three men on the other end. Occasionally a primitive form of pulley was used and on buildings exceeding three or four storeys a steam operated derrick was sometimes installed. For isolated low-lift operations such as timber or steel roof trusses the guyed mast has been used for a long time and in spite of the primitive character of this lifting device it can be very adaptable in skilled hands for many modern hoisting operations. A further development of the guyed mast is the guyed derrick type of crane which is so often seen in a mason's yard.



It is now quite ~~the~~ exception to see materials carried by hand up ladders; even the smallest of building schemes has a mechanical hoist of some sort. Simple hand operated telescopic pole hoists are now/

now obtainable that can lift a standard loaded wheelbarrow from ground level and slew it on to the various scaffold heights in small housing work. There is now a wide selection of small powered hoists capable of delivering bricks and mortar quickly on to the scaffold at the point of use. (89) Some of these mechanical hoists require special containers or special brick barrows. Prices range between £100 and £400 according to the capacity and speed of delivery and a good hoist operated by two men will deliver about 4000 bricks plus the necessary mortar in an eight hour day. In order to compare this with the servicing of bricklayers by hod-carrying labourers one must make a number of assumptions - assuming a rate of 800 bricks laid per 8 hr. day, five bricklayers would be needed to lay 4000 in an 8 hr. day. Under pre-war conditions the average contractor would rarely assign more than three brick and mortar carriers to five bricklayers, but at the present time (and assuming that labourers able and willing to carry hod or brickboard could be found) the proportion would more likely be four carriers to five bricklayers.

Thus the hoist should dispense with the need for two labourers and since, at current prices a small hoist costs about 2/6d per hour to operate, then the saving should be equivalent to the wages of the two men less 2/6d per hour. This/

This would work out at approximately £15 a week under existing conditions of production, assuming that there is no incentive or bonus scheme in operation. It is almost impossible to make accurate comparisons when operatives are working for a bonus or similar consideration because in these times of full employment the variation in production between bricklaying gangs working with or without/^{money}incentive is absolutely fantastic. A labourer in 1938 would make an average of at least twenty journeys an hour to any part of a two-storey building, carrying a minimum of eight bricks at a time. He worked $8\frac{1}{2}$ hours a day and would carry approximately 1360 bricks or an equivalent quantity of mortar in a day.

Under present conditions one can see brick elevators being fed by labourers when the distance from stock-pile to the point of use is less than eight feet! When the bricks could easily be thrown to the man on the scaffold in less than half the time that it takes to load and unload the mechanical hoist. This kind of thing frequently happens on building sites where operatives have lost the habit of manual labour and will sit all day waiting for a concrete mixer to be delivered, when hand mixing would have seen the job completed long before its arrival.

There is one point of similarity noticeable in many of/

of the small mechanical hoists manufactured mainly for small scale housing work - they are nearly all intended for use with an external form of scaffolding. This means that they cannot be entirely suitable for Scottish construction where the external walling is customarily built from the inside.

Some large firms in Scotland do, however, use these hoists, and the photograph shows such a hoist in a particularly favourable position - delivering bricks from the point where they have been tipped, to the point of use within the roof space where there is a party wall and chimney stack to be built.



This is an instance of the right kind of organisation with the right type of equipment. The site foreman has seen to it that the bricks have been tipped in such a position that one labourer can load the hoist directly from the brick pile, and another labourer can take them off the hoist and stack them on the scaffold. This second man may have to be assisted by a third labourer at the far end of the scaffold, or he may stack the bricks temporarily as they arrive from the hoist and then distribute them along the scaffold.

The earlier types of hand operated guyed derrick cranes have been developed considerably, and electrically driven examples of this crane are commonly used on large modern buildings. Sometimes they are mounted on towers and are called Monotower Derricks but the principle is still the same. A further adaption is the Stiff-Legged or Scotch Derrick which has a long reach and can lift a heavy load. All these cranes can be hand operated or driven by steam, diesel motor or electricity. Their main disadvantages are lack of mobility on the building site, a limited slewing action and the need for a considerable amount of free space within the building to accommodate the crane.

Prefabrication and the development of new building techniques involving larger building units have created problems of transport and hoisting that can only be solved by a travelling hoisting medium of some sort or a fixed hoist served by powered trucks. The mobile tower crane has the advantage of being able to handle materials both horizontally and vertically so that there is no need for the double handling caused by transferring materials from the stockpile to a powered barrow and then into the skip of a fixed derrick crane. Thus it is possible with a tower crane to reduce the number of small hoists and powered barrows/

barrows on any site.

Tower cranes are now manufactured that have the ability to virtually assemble themselves, the component parts - tower and boom, being hoisted into position by the main hoisting winch. The crane can slew its boom round in a complete circle up to 50 ft. or so in radius and lift up to 70 ft. or more. Motive power is usually provided by electric mains supply or by mobile generating plant.

The chief disadvantage of the tower crane is that its horizontal manoeuvrability depends on the rigid rail track over which it runs. This track must occupy valuable space on the building site and the track must run over level ground. Moreover, the majority of rail-mounted cranes cannot negotiate curves of less than 100 ft. radius, though it must be stated that this limitation on the crane's activities can be responsible for stimulating the contractor into planning his building operations around the crane, thus securing a more compact and concentrated sequence of operations.

In the construction of a compact block of flats the tower crane is an ideal hoisting medium. The pattern of house-building in Europe, where blocks of three to five storey flats are seen everywhere has for a long time encouraged the/

the use of this type of crane. In Great Britain, contractors have been relatively slow to recognise the advantages of the tower crane; this is understandable to some extent, for the widespread traditional British housing site is not always well suited to a railmounted crane which demands a reasonably level track to move over. The phasing of operations on such widespread sites to ensure the economic use of the crane demands considerable thought and careful planning. The crane must be kept occupied and time must not be wasted in travelling backwards and forwards over an extensive site in order to perform small isolated lifts. The capital cost including track, generating plant, etc. of a 40 ft. reach, 40 ft. lift tower crane suitable for a two or three-storey housing site is about £3000; this is clearly an expensive item of equipment which is costing money whether it is used or not.

Assuming a twelve year life, the annual capital cost of such a crane would be £250, and interest at say 6% would be £180 per annum. Add to this an annual charge for maintenance and repair of £150 p.a. then the total annual cost is £580. This means that the crane is costing the contractor nearly £12 a week during the first few years (reduced interest and salvage value might reduce this figure a little) when he is not using it. The cost would be a little/

little more of course when in use, but this rough calculation of the expense of an idle crane surely provides evidence enough of the necessity for keeping it in constant use.

The successful operation of a tower crane depends on other aspects of planning besides the general ^{of} phasing/lifting continuity. For example, scaffolding should be made up on the ground in sections so that the crane can lift an entire section into place at once; bricks should be delivered on pallets to facilitate the lifting of large numbers of bricks, 150 or so at a time, direct from the lorry. Normal sized mortar spots are awkward to replenish from a crane because they hold so little and it has been suggested that the continental tray type of mortar spot should be introduced into this country. The photograph shows Italian workmen using this type of container for mortar, it holds several cubic feet of material at one filling. The disadvantage of having a crane deliver such large quantities of mortar in one container is that it tends to dry up in the/



the centre and consequently requires frequent wetting.

A crane can reduce expense on brick-built chimneys by lifting three feet lengths of prefabricated chimney stack into place. The sections of the stack are made up by the bricklayers on the site, using a special frame on which the first course of bricks is laid and to which the lifting tackle is attached. This technique of prefabricating chimney stacks on the ground aims at reducing cost by removing the necessity for a high scaffold and the accompanying difficulties in servicing bricklayers on the scaffold. The ultimate three feet section of the stack is built complete with pot, flaunching and pargeting; the mortar bed is placed on the existing portion of the stack and the final section dropped neatly on by the crane. This operation is clearly a time-saving one, for "chimney topping" is rarely a fast process, where bricklayers are exposed to the worst of the weather and so much time is wasted on scaffolds, guard rails, access ladders, etc.,

The prefabricated stacks can be built under shelter at any time during the progress of the job. The plumber can rake out for his flashings while the mortar is still soft in the newly built stack. Building Research Station studies have shown that four units of prefabricated/

prefabricated stack can be lifted and bedded within 19 minutes. This contrasts well against the traditional method of building the stack, when vital roofing operations are held up while the slow operation of building the chimney stack is completed and the scaffolding taken down.

Trials have been made by the Building Research Station in which 32 houses were built with the aid of a rail-mounted tower crane and compared against 12 similar houses built in a conventional manner without the use of a crane. The trials showed that about 400 manhours per house were saved by using the tower crane on the shell of the buildings alone. Other savings totalling 600 manhours were attributed to the improved organisation that was in itself, essential to the efficient and economical operation of the tower crane. Altogether the saving on these trial houses was estimated at £100 per house after making allowances for the expense of the crane.

Although the results of these trials were generally satisfactory the Building Research Station Report (1954)⁽⁹¹⁾ stated that it is not yet possible to say much about the economics of using tower cranes because there are so many variable and unpredictable factors which prevent the complete and accurate analysis of cost. I consider that the question/

question that needs answering is why are tower cranes so popular with contractors in Germany, France, Italy and other European countries? In Italy, for example, contractors use these cranes even in the southern areas where labour is less than half the cost of that in this country and production on a manual basis is, from my own observations, far higher in Italy than here. Perhaps part of the answer is that architects and engineers in these countries design their buildings always with the use of the tower crane in mind? This is essential because a tower crane can only be operated economically when there is a methodical phasing of construction in order that the crane can have access to the maximum amount of construction before overlying construction such as floors prevents this easy access.

Convincing proof of the economy of the tower crane has been indicated by the example of the contractor who, in 1954 built the experimental eleven shops and maisonettes at Manchester in collaboration with the City Architect and the Building Research Station. ⁽¹²⁾ Tower cranes were used on this project in connection with the experiment and the contractor was so impressed by the economic advantages of the equipment that he ordered more cranes making up a total of five altogether. The contractor considered that the use/

use of tower cranes, together with the improved organisation essential to their use would effect an overall reduction in costs of 3% to 4%.

Mobile cranes other than tower cranes have their place on the building site. ⁽⁹³⁾ There are cranes mounted on pneumatic tyred wheels or caterpillar tracks that can operate vertically 20 to 30 ft. within a 25 ft. radius; these cranes are free to move anywhere on the building site and can be fitted with a cantilevered jib and pouring skip so that concrete can be placed inside the wall shuttering within precise limits. The limiting factor is the maximum height of the lift but there is undoubtedly much in favour of a crane which has complete freedom of manoeuvre, particularly on a widespread building site with houses not exceeding two storeys. Cranes with low-mounted jibs are handicapped on building sites because they always run the risk of fouling the nearest part of the building with the jib when servicing the interior of the building.

Quite often, a mobile crane serves as a basis for the adaption of it to serve other purposes. By fitting a special type of jib it may be adapted as a face or back shovel, skimmer, dragline grab or piledriver.

Palletisation and Packaging.

Palletisation is a new word for a new technique of parcelling up bricks into tidy packets or packages so that they can remain in this packaged form until they are placed on the scaffold at the exact point of use within reach of the bricklayer's hand. The bricks are dry-bonded as they are stacked on wooden pallets, and special barrows, crane grabs, forked trucks, etc., get under the pallet and transport the complete package of bricks on or off the lorry and on to the scaffold or wherever else they are required.

The chief difficulty experienced with palletisation has been the slow turnover of pallets, for it is necessary quite often to stockpile the palletised bricks on the site to ensure against delivery delays, and this means that a very large number of pallets may be kept out of use.

When the Building Research Station experimented with tower cranes on the Norfolk housing site, ⁽⁹¹⁾ the bricks were delivered on to the site in the normal way and then stacked on pallets, 160 at a time. This assisted the tower crane to place the bricks on the scaffold without loss of time but there was obviously a great waste of time in the double handling of the bricks before the tower crane came into the picture. It was estimated that a further saving of approximately/

approximately 35 manhours per house might have been saved if the bricks had not been handled twice. It should be quite clear from this experience that the full advantages of palletisation can only be realised when the bricks are lifted or otherwise transported direct from the lorry to the actual point of use.

Systematic research is going on in this country, in Germany, Sweden and elsewhere, ⁽⁹⁴⁾ enquiring into the most suitable size of brick package, the best shape for transport and handling and the suitability of the various types of special barrows, cranes, etc., to deal with the system of palletisation. It has been shown that palletisation can be economically useful even if there is no crane on the building site, for lorries are now being equipped with hydraulically operated cranes, powered by the lorry engine itself, and capable of loading or off-loading palletised bricks, concrete mixers and other heavy components.

The importance of palletisation has been recognised by the recent publication of a British Standard for Pallets for Materials Handling (BSS 2629) in which pallets are specified in six standard sizes suitable for most forms of transport including the latest models of fork-lift and pallet trucks. Sketches and useful data in this B.S. give guidance to the industrialist concerning the sizes, weights and/

and shapes of loads that can be handled at each stage between manufacture and point of use.

A British contractor has recently developed an interesting device for transporting packages of bricks by crane without making use of the pallet except as a base for the initial stacking. ⁽⁹⁵⁾ The device is in the form of a metal box incorporating a scissor grip which forces the bottom layer of bricks together and holds them as if in a vice. The stack of 196 bricks can then be raised on this supporting layer of bricks, leaving the pallet behind to be loaded up again. As a safety precaution a strong metal safety plate is swung into position and clamped under the box in case the pincer action of the equipment should fail.

This "brick grab" should certainly help to reduce double or treble handling of bricks on the site but it does not appear to aim at the complete removal of handling between the manufacturer's yard and the scaffold. Also, it is not easy to understand why all the bricks in the package are stacked upon edge; quite obviously the bottom layer must be on edge in order to assist the clamping action by presenting a greater area of contact. But the bricks in the upper layers ought to be laid flat so that the bricklayers can take them "as they come" and place them in position on the wall without the need for "spinning" them and the consequent loss of time.

This/

This independent research and experiment by a contracting firm in producing such a useful piece of brick handling equipment is most commendable, but it is one-sided; the brick manufacturers should be co-operating more than they are in these efforts to reduce handling costs. Perhaps the reason why the manufacturers are not co-operating is that they can see little profit in it for them. All they are doing at the moment is filling the lorries at the brickyard and then sending in the bill; the demand for bricks has hardly slackened in ten years and judging by the standard of some of the common and facing bricks supplied during recent years it is manifest that manufacturers show little interest in the quality of their bricks and consequently are not likely to bother unduly about the contractor's problems of site handling. In the U.S.A. it seems that the the contractors are able to call the tune a little more than the British contractors are able to and manufacturers are having to co-operate in the successful working of systems of palletisation of bricks on a number of large contracts.

The combination of crane and a packaged load surely has possibilities beyond palletised bricks and blocks, the prefabricated frame of scaffolding has been hoisted in position by crane to a limited extent and prefabricated chimney/

chimney stacks, built on the ground have been quite successfully dropped into position by crane. In Italy, packages of bonded dry stone walling have been made up in the quarry and parcelled up in chainlink mesh for convenient lifting by crane on to lorries. The packages are then transported out to the site and transferred by crane directly into their final position. This has been done on quite a large scale by the Italians, mainly on retaining walls, dams, etc., concerned with river and road works. The packages of bonded walling are made up in a fairly



standard size of about one yard cube and are placed side by side in rows with a slight batter. Subsequent courses are laid dry on top of the first course so that each following course of "packages" is half-bonded over the course immediately below and all joints are broken as between packages.

This technique of concentrating the mason

labour force in the quarry and building the wall sections under/

under ideal working conditions has many obvious advantages, and some consideration might usefully be given to the application of the technique in one form or another to wall or pier construction in multi-storey housing. For example, might it not be possible to build brick piers on the ground, hollow in cross-section and in three feet lengths or so. The hollow pier /could be placed in position by crane and could then perform the function of permanent shuttering for a reinforced concrete filling; the reinforcement should not be difficult to fix and the pier sections could be threaded over it. The brickwork might be in a $4\frac{1}{2}$ in. thickness, half-bonded and bedded and jointed in a fairly strong mortar to ensure resistance to stresses set up by the hydrostatic head of poured concrete.

This permanent brickwork shuttering could be built in facing bricks or keyed for plaster according to the particular requirements of the building, it could be reinforced by expanded metal and this form of reinforcement could be built in to serve the purpose of tying in panel walls or infilling. The bricklayers would work under cover, and the pier sections could be built on special frames suited to the hoisting arrangements. If pier sizes were standardised it might even be possible to build the brickwork within a "jig" or frame and thus reduce wasteful plumbing time.

A bricklayer is responsible for placing in position nearly 60% of the entire weight of a house, and to do this he has been using almost identical tools and methods to those which his forbears have used for over two hundred years. This would suggest that the ideal shape and size of hand tools was arrived at long ago, yet why is it that a British bricklayer uses a trowel which is differently shaped to that which a Polish bricklayer uses ? or why does an Italian builders' labourer use a long handled shovel for his work when a British labourer does the same kind of work with a shorter and completely different type of shovel?

Many European bricklayers use a shallow box or tray instead of the flat mortar spot favoured by the British bricklayer and Italian plasterers are more inclined to throw plaster on to interior wall surfaces rather than ^{use} the trowel and handhawk method commonly adopted in Britain. Even the size of the brick varies from one country to another. Dutch bricks are much smaller than those we are accustomed to in this country. Italian bricks are longer/



longer and wider but measure only about two inches in thickness. Even between Scotland and the south of England there is a difference; the Scottish bricks being about $\frac{1}{2}$ in. or more longer in every dimension. Again, the Scottish wall-builder works from the inside of the building on a scaffolding built up from the various floors, yet the bricklayer in England invariably works from the outside on a system of scaffolding framed up on the perimeter of the building.

These differences in equipment, materials and methods suggest that the rationalisation of craft methods could advantageously be investigated on an international basis. Time and motion studies should show, for example, what is the right size and shape of trowel for maximum production coupled with good workmanship. The correct type, height and spacing of mortar spots for maximum production could be found by operational study, and also the most suitable height and spacing at which bricks should be supplied to the bricklayer.

Studies of this kind have been carried out in America and Russia and to a lesser extent, in this country, but nothing, or very little, appears to have been done on an international basis. This is unfortunate and may well be uneconomic for some countries using traditional tools or processes which are wasteful or inefficient by comparison with those used in other countries.

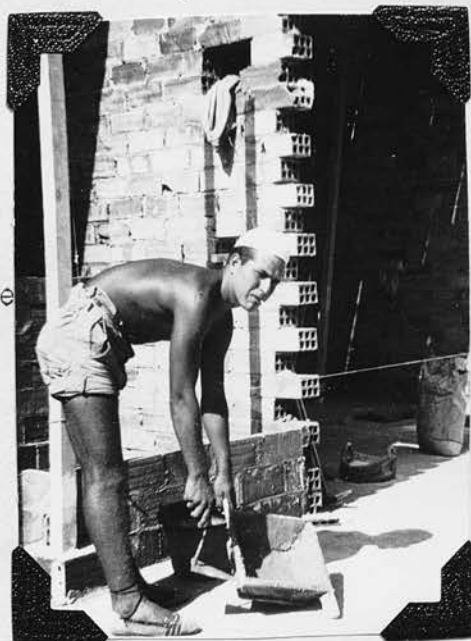
A mortar scoop has been used in Russia and several other countries for the purpose of spreading mortar more quickly and more evenly. This item of equipment has been used mainly for walling of large-sized building blocks, though it is claimed that it could be used advantageously on long lengths of brick cavity walling.

The scoop has a volume of about 6 litres and is thus reckoned to hold about nine times as much mortar as an ordinary trowel. The scoop is used in conjunction with a metal sledge which slides along the wall and guides, or channels, the mortar from the scoop along the bedding surface of the wall.

At the same time, the open perpend in the wall are filled up as the scoop and sledge pass along the wall. It is claimed that for walling in straight lengths the time normally taken to spread mortar is reduced by more than half.

Clearly, this technique of spreading mortar could only be successful where large walling units are used and where the blocklayer has to take both hands to lift the unit. In ordinary brickwork the bricklayer has to turn or bend when he requires a brick and he usually takes a trowel of mortar at the same time. Again, I doubt whether the open cross joints or perpend would, in fact, be properly filled as the sledge passes them without some assistance from the bricklayer with his trowel.

The Spanish bricklayer shares the preference of many Continental craftsmen for the mortar spot with raised sides. The photograph shows a typical bricklayer in Tarragona in the act of taking mortar from this type of container and it will be noticed that there are specially formed handles at diagonally opposite corners for his convenience in raising the container to a more convenient angle for removal of the mortar. On this particular site the bricklayers were provided with dry-mixed mortar in a basket container (seen in the background to this picture) and it was left to the bricklayers themselves to add water to the mixture as and when fresh mortar was required. This was of course, partly due to the excessively hot and dry conditions under which work is usually carried out in Spain, where temperatures during a working day go above 80 degrees in the shade. Another explanation for these Tarragona bricklayers mixing up their own mortar appeared to derive from the low ratio of labourers to craftsmen that obtained in the provincial and southern areas where the minimum wage rates are paid and the difference between skilled and unskilled/



unskilled workers' rates of pay is negligible, so that it matters little who mixes the mortar in such circumstances

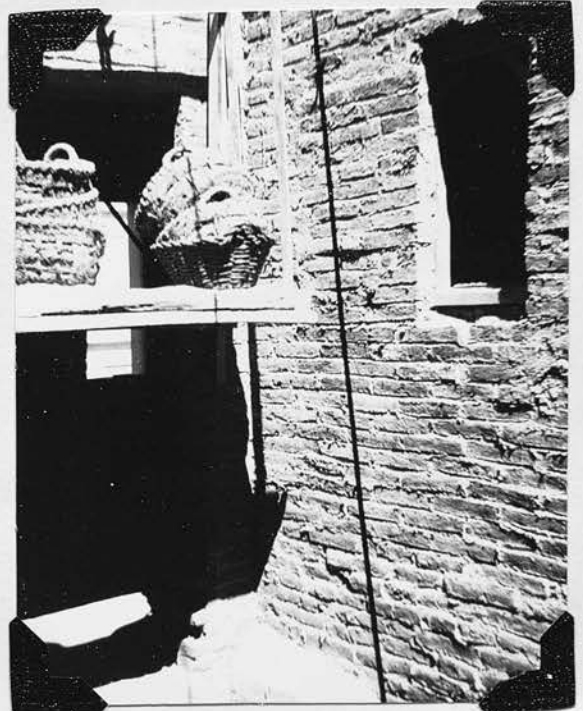
The type of trowel used by the Spanish bricklayer is very different from the kind of trowel which is generally used in this country. The shank of the trowel is about six inches long, the blade is very small and the handle is cranked up from the shank at an angle of roughly 60 degrees to the horizontal instead of the usual 20 degrees or so of the handle to the British type trowel. With such a strangely shaped tool it seems incredible that the Spanish bricklayers can lay bricks, cut, trim and point them with a facility that seems equal to that which our own craftsmen attain, but using a very differently shaped tool.

Wheelbarrows similar to our own are in use on most Spanish sites but baskets are more commonly used to transfer aggregate and mortar materials to mixing points. It is quite usual to see concrete aggregates being carried in these baskets to a modern concrete mixer. The photograph on the next page shows this happening on a site where the foundation to luxury flats in Barcelona are being constructed, and the second photograph shows a pile of empty baskets returning from an upper floor where concreting aggregates are being used.



One man is operating the concrete mixer and six labourers are filling and carrying baskets of aggregate to the mixer. A barrow is used to transport and place the concrete.

Baskets coming down to the ground floor where they will be filled with fine or coarse aggregate.



Fireplace Openings and Flues.

The size of a chimney breast in the average domestic building is usually determined by the size and type of fireplace fitment favoured by the general run of tenants and owner-occupiers. A minimum width of 4 ft. 6 in. to 5 ft. in a living room is quite common with a fireplace opening of 2 ft. 3 in. or so. Assuming a minimum projection of jambs on an internal wall to be 14 in. and taking as an example a room about 12 ft square, then the chimney breast thus takes up 6 sq. ft. or approximately 4% of the available floor space, and a similar percentage of cubic space in the room .

Added to this the side recesses left besides the chimney breast are often inconvenient for furniture arrangement, especially when they are reduced below a three ft. width. With the current type of fireplace surround there is little that can be done to reduce the size of the chimney breast; in some contemporary room designs the breast wall is planned to divide the dining recess from the living room and immediately above the fireplace the wall may be curtailed up to the side of the flue. This arrangement is quite helpful but in the great majority of conventionally planned rooms the 5 ft. by 14 in. chimney breast continuing right up to the ceiling is simply a sheer waste of bricks, mortar/

mortar, decorative material, etc., apart from the not inconsiderable reduction in living space. The chimney breast ^{two-storey} in modern/housing is mainly confined to the ground floor and is seldom called upon to support fireplace and chimney construction in the floor above. Its function therefore is to contain the flue, ^{to} /support the brickwork containing that flue and to present a facade against which the fireplace fitment stands.

The use of free-standing stoves combined with revised by-laws permitting some form of flue block incorporated in the wall would help considerably towards more economic building. The L.C.C., in the eleven-storey Picton St. flats, ⁽⁹⁶⁾ are experimenting with glazed fireclay flues, circular in section, 6 in. diameter, and built in a 10 in. mass concrete wall. This wall is the main cross-wall separating one flat from another and the effect of the experiment is that a flush wall is obtained without wasteful chimney breast or fireplace opening, merely a 6 in. circular aperture in each living room to which a closed stove appliance is connected. It will be interesting to see how this works out when the typical housing tenant, usually so antagonistic to the closed stove, has subjected the system to the searching tests of ignorance and indifference.

In considering what could be done to reduce this long established but wasteful and uneconomic method of providing for fireplace and flue it might well help to turn back the clock and look into the early development of the chimney breast wall. The first improvement on the hole in the roof of the baronial hall was the forming of a hood over the fire to conduct the smoke and flue gases to the constricted development of the upper part of the hood and thence through the roof to the outer air. Then the fireplace opening and side jambs gradually evolved from the necessity for containing the fire safely on three sides, and from this the chimney breast was an obvious development.

But the modern slow-burning stove or special coke-burning appliance does not require the same degree of protection and this is gradually being recognised in building regulations and model by-laws inasmuch that their main provisions for such appliances are directed to the construction of the hearth on which the appliance stands. It seems to me that there is a lot to be said for a simple fireplace built on the hearth, open to three sides with a hood corbelled out above the fire - taking the smoke and gases away through a flue developing from the hood and occupying the very minimum of space within the room. Such a flue with its encasement would probably project beyond the face of the wall but this could/

could possibly be developed as a decorative feature.

Much nonsense is talked about flues being properly "blinded", and no really satisfactory reason has ever been given for this insistence on a flue following a tortuous path instead of continuing a straight and upright course. Unless a flue has to be taken to one side of a chimney breast in order to fit in beside fireplace openings on upper floors, there seems to me to be no good reason for twisting the flue this way and that, simply to ensure that any rain, supposing it ever descended in precisely a vertical direction, should not fall on to the hearth. Bends in a flue mean additional length and additional resistance to the smooth and easy flow of flue gases, therefore they should be avoided wherever possible.

In forming traditional type fireplace openings, increasing use is being made of special precast flue units which are built in at lintel height and serve both as lintel and a pre-formed throat. This photograph shows a typical unit turned on its back. The throat/



throat is clearly seen, reducing to a circular flue about 8 in. in diameter. In the photograph below the unit is seen built in place, an additional precast component, wedge-shaped, fits in to the front of the unit immediately below the lintel.

These precast units save a great deal of brick cutting in forming the throat and developing the flue. Quite often this work is badly done and the efficiency of the fireplace and flue suffers in consequence. The cause of downdraught is more often than not located in the forming of the throat, and few bricklayers are conversant with the research and subsequent recommendations of the Building Research Station on the proper size and shape of the throat.

Usually, circular flue linings are used together with these precast units, and there is little doubt that a more efficient flue is obtained thereby, for it will be uniform in diameter throughout its length, and will offer less resistance to smoke and gases than a square, indifferently pargeted flue which has been formed in brick in the normal way.



Methods of domestic chimney flue construction in Italy are very different to those adopted in this country, Italian building regulations appear to permit flue sizes and surrounding brickwork thicknesses that fall far short of our own model byelaw requirements. The chief reason for these greater tolerances in the Italian regulations is, I think, due to the fact that they have no open fires and all solid fuel burning equipment is of the slow combustion closed stove type. The scarcity of coal imposes a discipline on Italian design of domestic heating and cooking equipment that is most noticeable in all classes of buildings, one rarely sees the skyline of smoking chimneys which, unfortunately, is such a familiar feature of the British townscape, and space-wasting chimney breasts continuing through successive storeys do not occur in the Italian layout.

The type of flue I saw in most of the detached houses was simply an asbestos-cement pipe about four inches in diameter, built into a chase left in the external hollow block walling and terminating just above eaves level in a patent type ventilator cowl. At the lower end the circular flue opening was left for the stovepipe connection, usually twelve inches or so below ceiling level. Quite often the occupant of the house is expected to bring in the stove of his choice and/

and he is responsible also for fixing it. The stove is, in fact, what we should regard as a tenant's fixture.

Floor construction is invariably in reinforced concrete and hollow clay blocks, finished in terrazzo or patent composition, consequently no special provision for a hearth is considered necessary. Most of the stoves have a metal base with a turned up edge to catch falling ashes and this appears to left to the occupant to provide and renew as he sees fit.

In Milan I saw several blocks of flats which incorporated a system of flue construction patented by a Dutch firm. Stated simply, this method consists of special precast concrete flue blocks (see photograph) providing one large main flue about 8 in. by 14 in. and two small flues $3\frac{1}{2}$ in. by $4\frac{1}{2}$ in. each. The flues are rectangularly shaped and the thickness of the concrete separating and surrounding the flues is just over an inch. The inner surfaces of the flues are not meant to be pargeted and are left with the concrete finish as from the mould.

The "canna fumaria generale" (the main flue) is meant to take the fumes from successive appliances on different floors which are situated more or less vertically in line with/

with one another. The basic principle of the system is that all the appliances connect, in the first instance, to one of the smaller flues so that each individual appliance has an entirely separate flue with an initial run through one storey height before joining the main flue and by this means the danger of downdraught carrying in fumes from a stove on another floor is minimised. A further insurance against downdraught is provided by fixing a specially designed louvred cowl at the top of the main flue.

I noticed that these flue blocks were also used for ventilation shafts providing permanent ventilation in bathrooms, lavatories, kitchens, etc., where this type of ventilation happened to be necessary. The principle of storey-height separation was observed as for the smoke stacks and although the ventilation shafts were separated from the smoke shafts they were often built side by side in the interests of constructional simplicity.

This method of chimney flue construction undoubtedly falls far short of our own standards in this country, ⁽⁹⁷⁾ but, after all, the system does what it sets out to do - it provides for the efficient disposal of fumes from closed stoves. The emphasis is of course on closed stoves, for obviously such a system could never cope with the open fire with its deplorably inefficient/

and incomplete combustion process. This is perhaps one of the few aspects of the British way of life that we should do well to change for the open fire is undoubtedly wasteful of coal and the flue construction that we must provide for disposing of these waste products is extravagant in living space, building materials and labour.



Stack of patent flue blocks on a site in Milan where tall blocks of low-cost flats are under construction for the Istituto Nazionale per le Case degli Impiegati dello Stato - I.N.C.I.S.

FLOORS

In any examination of new types of floors some preliminary consideration is bound to be given to the controversial issue of solid floors versus wood joisted floors. For hundreds of years, timber floors have been used in house-building and it was not until 1945, when the scarcity of imported softwood made solid floors compulsory in ground floor construction, that builders were forced to use alternative forms of floor construction.

The solid ground floor has in consequence been fully developed, suitable surfacings have been produced - notably in the form of thermoplastic tiles - and there seems little doubt that this enforced change in the method of floor construction has, indirectly, made a worthwhile contribution to building technology and to the ever-widening range of building materials.

Since the licensing restrictions controlling the sale of softwood were removed on Nov.13th. 1954, many architects are specifying timber joisted floors again for ground floors. Their reasons for doing this are probably due to public preference for the conventional type of floor and also because timber flooring is more resilient, warmer to the/

the touch and less likely to encourage condensation. Those who favour solid floors usually argue that the risk of rot infection or insect attack is removed, and thermal insulation is improved because there is no necessity for the vigorous circulation of air under the floor as there is in joisted floors and consequently there is no wasteful dissipation of heat from a room.

So far as ground floors are concerned, these are the main arguments concerning the two basic types of construction, except, of course, for the most important factor of cost, which is bound to have a strong influence on the choice of system. In 1951, R. Fitzmaurice published comparisons of cost in the Architects' Journal ⁽¹⁹⁾ and it appeared that a timber floor on sleeper walls cost 32s.2d. per yd. super against 3ls.9½d. per yd. super for concrete solid floor with a suitable surfacing material. Taking items from a 1955 priced schedule for Scottish housing work where alternative prices were given for the two types of flooring, the prices were as follows:-

Timber floor on sleeper walls, (with hardcore, bottoming and ½ in. asphalt d.p.c.)	£56.14.0.
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Solid/

Solid floor consisting of hardcore, bottoming and d.p.c. as before, with $3\frac{1}{2}$ in. concrete and patent floor finish. - £53.10.9.

The prices were per house and it is seen that the solid floor is again the cheaper. Moreover it must be appreciated that the housewife is almost bound to cover the timber floor with linoleum or carpet, while the patent finish on the solid floor may be quite reasonable in appearance and may not involve further expense in floor coverings. This mention of the additional cost of floor covering for bare timber floors may seem a little removed from any calculation made by a prospective house-owner, as also may be the prospect of fuel saving resulting from a solid floor. But these are matters which are inescapably linked with cost and must be studied and given due weight, as they may well be by a more cost-conscious public in the near future.

Reference has already been made to the possibility of reducing building cost by replacing the conventional scarcement with an inexpensive form of brick corbelling, and it seems to me that there is another wasteful form of underbuilding that is often occurring in housebuilding where/

where the space beneath timber ground floors is excavated far more deeply than is necessary. On a level site, it should not be necessary to do more than remove the top 18 in. or so of earth from the site within the outer walls of the building, for if the wall d.p.c. is a minimum of six inches above the outer adjoining ground level, and the floor joists are above the level of the d.p.c., then there will be at least two feet below the underside of the joists before the hardcore and site concrete is placed. Allowing, say 12 in. altogether for this, there is still 12 in. clear space between the upper surface of the site concrete and the underside of the floor joists. And this is ample, for quite a sufficient circulation of air can be obtained in such a space to ensure adequate ventilation to the floor.

Many contractors appear to consider that there is some constructional merit in creating a deep space below the floor joists, and that by so doing the insurance against dry rot is increased. On the contrary, an excessively deep underfloor space may, and often does, act as a sump for surrounding ground moisture to drain into, with the consequence that conditions favourable to dry rot are set up./

up. This being so, it is plain folly to waste money on such excavation work when a better job can be done without it. It is well appreciated, of course, that some sites undulate to the extent that deep underbuilding is unavoidable, also it may be thought to be a good thing to have plenty of room below ground floor joists in order that the householder may be able to gain access to the underfloor space for inspection purposes. This last point is hardly worth serious consideration however, for it is rarely possible, with normal sleeper wall arrangements, to secure access to all parts of the underfloor space, unless trapdoors are sited in every bay of the floor.

A further saving in cost could be made if the underfloor space was restricted to three inches or so below the underside of the joists, for in that case there is no need to build continuous walls for the support of the joists and individual bricks could serve the same purpose. This has been recommended by the Timber Development Association and there is much to be said for this economic form of underbuilding. When sleeper walling is reduced to this extent more supports may be used and the span and depth of joists reduced - thus achieving still further economies.

Precast Concrete Floor Units.

When upper floors in multi-storey buildings are considered, there are additional factors such as sound insulation and fire resistance that assume far greater importance than in any consideration of ground floors. It follows then, that in the interests of fire resistance alone, the construction of upper floors must be in fire resistant materials, and such materials may range from steel beams with solid concrete filling to hollow clay block infilling combined with reinforced concrete ribs and topping.

In the current edition of Specification (The Architectural Press), almost forty pages are devoted to the many different types of patent floors. Most of them are too elaborate and expensive for house-building, for they involve special factory production processes, transport costs and quite often the additional cost of specialist fixers.

The prestressed concrete slab beam in the form of precast units is probably the cheapest **type** of the listed patent floors but unless some form of floating finish is designed for it the degree of sound insulation is hardly likely to more than 50 decibels, and this is hardly enough for floors in flats.

The/

The normal type of prestressed concrete plank floor available in this country is laid in a minimum composite thickness of four inches and consists of a 2 in. plank plus 2 in. of "in situ" fine concrete topping. This depth of floor will safely withstand a load of 50 lb. per sq. ft. over a span of 15 ft. For very light loadings of 15 lb. per sq. ft. maximum it is possible to reduce the total floor thickness to 3 in. by providing only 1 in. of topping, but light loadings of this order are hardly worth considering here.

The advantages claimed for this type of flooring are mainly based on the fact that no shuttering is required as with normal "in situ" concrete floor construction, yet there is sufficient "in situ" work to impart a reasonable degree of monolithic stability to the floor. Services can be accommodated in the voids within the floor thickness, the underside of the prestressed concrete planks can be pointed where plastering is unnecessary or otherwise keyed to receive plaster.

(99)
A field test of one proprietary floor of this type was recently carried out in the presence of the L.C.C.'s technical staff with the object of confirming the accuracy of the producer's design methods. In the test a stretch of floor/

floor, three feet wide and nearly 13 ft. clear span was uniformly loaded up to a maximum loading of 280 lb. per sq. ft., this loading was a little more than four times the loading for which the floor was designed. The deflection at mid-span under the design load of 62 lb. per sq. ft. was 0.005 in. and increased to 0.057 in. under the maximum loading. The recovery after removal of the test load was within 7% of the maximum deflection.

In other tests on the precast prestressed floor, (not carried out in the presence of the L.C.C. representatives) an investigation was made into the effect of inferior workmanship in the prefabricating factory or on the site. The main points considered were the lateral bonding between the prestressed planks, the bond between the topping concrete and the planks, and the effect of prolonged overloading. The methods of testing were quite interesting- in one test a layer of paper was inserted between the flushed up planking and the concrete topping so that there could be no bonding strength between the two. In other tests poor quality concrete was used and the normal precaution of temporarily propping the centres of the planks was omitted.

Generally, the ratio between the applied bending moment at failure and the design resistance moment was no worse/

worse than 2:1, and when the test load of $1\frac{1}{2}$ times the design load was left in position for twelve months it was claimed that there was no sign of cracking after this, nor was there excessive deflection recorded, and in every case what deflection there was disappeared when the test load was removed.

A test load of only $1\frac{1}{2}$ times the load for which the floor was designed is hardly what one might call an exacting test, whether it is applied over twelve months or twelve years. And whatever the other tests may prove there is little doubt that these floors are not standing up well to general usage, for in many instances there is movement, due to deflection, or maybe through moisture, and this movement is causing disfiguring cracking to appear along the line of the individual slabs where plaster. has been applied direct to the underside of the slabs. In a number of instances I have noticed that the slight camber due to prestressing has shown up badly against internal facing brick courses in local schools.

This type of floor construction has been used in a number of Edinburgh's housing schemes and it would seem that the tenants have voiced considerable criticism of the sound-proofing qualities of the floor in addition to a general complaint arising from the cracks in the plastered ceilings.

The photographs here show this type of precast pre-stressed unit floor during the placing of the beams. In the first picture the workmen are transporting the beam from the point where it has been delivered by derrick hoist to its final position in the floor. The speed at which the team of four men worked was quite impressive. After the initial difficulty in laying the first few beams near to the hoist in order to create a working platform the work was



reduced to a simple repetitive drill. Each man knew what his



particular task was and the time taken to receive a beam from the hoist, turn the pneumatic tyred conveyor round, wheel it across the floor, slide it on to two temporary rods and then take them out, took no more than four minutes altogether.

According to the manufacturers of prestressed concrete plank floors the price should work out appreciably lower than ordinary "in situ" floors, but this is a short-sighted economy if the construction is not going to be completely satisfactory and if, for example, some form of suspended ceiling has to be used with the plank floor.

The use of suspended ceilings as a constructional technique is important enough to warrant separate consideration in this examination of flooring techniques. There is little doubt that the suspended ceiling can do much to improve sound and thermal insulation, and plaster cracking, pattern staining and other difficulties experienced with direct plastered ceilings are removed at the same time. Moreover, the suspended ceiling presents a ready-made duct in which building services may be housed, and where there are intervening Tee-beams or the like, the suspended ceiling can be sited so that a completely level surface is obtained.

These advantages of suspended ceilings are, of course, generally known and appreciated. But the cost of such construction inevitably rules it out of any serious consideration in the design of domestic buildings. It may be that a cheap form of dry suspended ceiling construction could be developed in combination with the prestressed concrete/

concrete plank floor. In my opinion the most likely development is on the lines of a demountable dry ceiling, possibly of sheets of stiff insulating board, placed simply on a horizontal framing connected to hangers built into the joints between the precast prestressed planks.

An interesting and unusual method of constructing a suspended ceiling has been used in the United States and is available on the open market at a reasonable price. It consists of a very light sheet of material, in appearance something between cardboard and paper, which is rolled out on a framework of suspended metal runners. The material is readily taken down for cleaning purposes or for access to services behind it. So far, it has only been used once in this country, in a garage in West London.

It is doubtful whether such a ceiling would be entirely satisfactory in house-building, particularly if used in municipal houses where a problem has already been created by irate tenants showing their disapproval of "noises above" by hammering on the ceiling with the end of a stick and producing dents and marks in the plaster! However, the idea of buying ceiling material in a roll is worth careful consideration for houses occupied by responsible tenants, but it must be at low cost to compare with normal plastering methods. Dry suspended ceilings are obviously popular in U.S.A. where plasterers are paid 25/- per hr.

Reference has already been made to a modern system of flooring in this country consisting of precast pre-stressed concrete planks supporting clay blocks. This is the Stahlton floor manufactured by Costains,⁽¹⁰¹⁾ and it is quite expensive. A progressive Musselburgh contractor⁽¹⁰²⁾ has developed a similar floor, but with an infilling of clinker-block instead of hollow clay or concrete filler blocks.

The photographs clearly portray the sequence of the construction of the floor. Here The floorlayer is working off the the pre-stressed planks and is placing the clinker-block filler in between the planks.

Hoops of reinforcement protrude from the pre-stressed planks and in the first instance these hoops assist the handling of the planks

but the primary purpose of the reinforcement is to bond in with the lateral distribution bars and prevent the common failure of this type of floor - the ceiling cracks due to uneven deflection.

In/



In this photograph the pre-stressed planks are seen resting on a 9 in. solid cross-wall and the floor is almost ready for the application of the fine-concrete topping which is meant to level off the floor and spread the superimposed loadings in such a way that uneven deflection and cracking in the ceiling below is not possible.

This particular floor system is quite new and its designers have not had opportunity yet to observe fully the effect of unequal drying shrinkage and other movement that may take place through moisture etc. Further developments are taking place, a dove-tailed shaped bonding piece is now being cast integrally with the precast pre-stressed plank so that the lateral bond may be further improved, and other improvements are contemplated.



~~Another form of pre-stressed precast concrete floor is shown during placing in the photograph on the next page. This site is at Sighthill, Edinburgh, and the floor slabs are made~~

Hollow Clay Block Floors.

The hollow clay block has been used in patent floor construction for many years but in this country its use appears to be declining in favour of the precast reinforced concrete slab beam. On the Continent however, the hollow clay block is commonly used in floor construction together with reinforced concrete and in Italy it would be true to say that this ubiquitous building unit is used in constructing floors in almost every type of building throughout the country. This photograph, for example, shows a detached house on the Adriatic coast which has floors combining clay blocks and reinforced concrete, and in addition to this the ceilings, roof and walls are constructed with



hollow clay blocks.

The Italian builders are remarkably versatile in the use of these blocks and have developed many novel forms of site prefabricated beams incorporating the blocks. The usual method is to place a number of blocks end to end to make up the required length of beam. This is done on a

prepared base and the blocks are thoroughly wetted and reinforcing/

reinforcing rod laid along the channels formed at the sides of the blocks. The photograph shows a stack of Italian hollow clay blocks which have these channels specially formed during extrusion

A third channel is seen in the top of the blocks and it is usual to place reinforcing rod here also.

The building operative then points a fillet of strongly gauged cement-mortar over the reinforcement so that it is welded, as it were, to the side of the block. Immediately



the first beam is formed, a second beam is similarly cast and is supported on the first beam with a separating layer of sand preventing any adhesion between the beams.

The photograph on the following page will show how a stack of a dozen or so beams is made up in a continuous operation and on a very limited area of site. When the stack of beams is completed it is left for a minimum of ten days for the cement-mortar to harden off thoroughly. The beams are then ready for use. Usually they are employed in floor construction/

construction in much the same way as prefabricated slab beams of reinforced concrete are used in this country. The saving in cutting out the necessity for close-boarded shuttering must be quite a consideration on a large project, for the only support necessary is one or two props in mid-span, according to the length of the beams.

When the prefabricated "block/beams" are placed in their final position in the floor, the projecting channels housing the reinforcement at the sides of the blocks serve to space out the main body of the beam so that between the beams there is a 3 in. channel in which more reinforcement may be laid before the entire floor is flushed and covered with fine concrete in the same way that the patent hollow clay block floors have always been constructed in this country.

These prefabricated beams are also used for ceiling construction on upper floors where the attic space is not intended to be used. In such instances the beams are simply placed alongside each other so that they present a flush surface/



surface on the underside for plastering and the top surface is flushed up with fine concrete . Quite often a deeper clay block is made up into a prefabricated beams in the same way and is used as a ceiling joist at about a three feet spacing. A layer of special clay blocks, three feet in length, is placed between the flanges of the ceiling beams, the blocks being rebated so as to notch on to the flanges and thus present a level soffit for plastering. This form of ceiling construction is quite common in detached houses on the Adriatic coast of Italy, some of the prefabricated "block beams" are made to span 18 ft. or more and from a personal inspection they appear to be quite strong and adequate for their particular purpose.

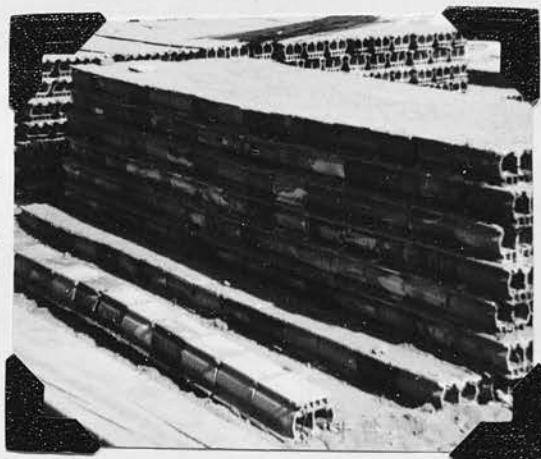
The photograph shows more of these beams in the process of prefabrication in a builder's yard near Venice. In this instance the beams are being made to form cambered roof members. They are to be used in roofs on agricultural buildings, garages, etc. The method of construction is quite simple, /



simple, the beams are placed side by side and then concreted over in the same manner as the floor beams. The protruding ends of the reinforcement are carefully tied into "in situ" concrete wallplates and then the roof surface is covered with interlocking clay tiles.

From this description of the site prefabrication of these "block/beams" it will have been evident that the work involved is extremely simple so that a stack of beams can be made up in a matter of a few hours. The whole operation can be undertaken by a semi-skilled man who simply lines the blocks up, wets them, places the reinforcement and then points a rough cement mortar fillet over it.

The very simplicity of this sequence of operations must make the manufacture of these beams an attractive proposition to the small contractor, for he has no expensive factory to equip or machinery to buy. All he requires is a flat piece of ground on the site or he can, if he wishes, build a rough shelter on the site so that the beams may be prefabricated during wet weather.



~~Structural~~

also use
The Spanish builders/a specially shaped hollow clay block to make up prefabricated beams for floor construction. The photograph shows a stack of these beams all ready for placing across the particular floor span, and it will be noticed that these beams are reinforced with quite heavy mild steel bars, bedded with cement-mortar in the special recesses formed in the clay blocks. The blocks are butt-jointed in cement-mortar.

Beams manufactured by the Italians are very similar to these but greater use is made in Italy of the hollow clay block with projecting side-flanges which, in addition to containing the reinforcement, also act as "spacers" between the beams so that reinforced concrete ribs may be cast in situ as in normal



floor construction of this type. Here, it is intended that the prefabricated block beams themselves should carry all the loading and they are merely placed close to each other as they lie across the floor span, the protruding ends of the reinforcement are cast into the supporting walls or r.c. primary beams, and the surface of the floor is then finished with a cement-mortar screed.

where reinforcing rods are placed inside certain of the¹⁹⁶ voids running through the butt-jointed block beams, these voids being filled then with fine concrete. The method of casting beams in this manner is seen in the background to this photograph, where blocks making up a row of beams are stacked vertically against the wall and temporarily stayed while reinforcement and concrete are inserted.

It is remarkable how effective this method of beam prefabrication can be - even when the workmanship is as primitive as the photograph suggests. These particular beams were being used for all kinds of purposes ranging from lintels to floor beams.

Lintels made in this manner and used with the blocks on edge would be quickly made up to any reasonable * length. The best method of manufacture would probably be to provide reinforcement and concrete filling to the lower two voids and concrete alone to the upper two voids. This should provide effective tension and compression flanges.

- * (The Clerk of Works in charge of the Heriot-Watt College 3rd. Extension, Edinburgh, has been interested in my experiments with these beams and has persuaded the contractor to try out lintels made up from hollow clay blocks).



Structural engineers in this country would probably look askance at what seems to be a rather crude site method of making a structural unit destined for a loadbearing function in a building. Indeed, it does seem hard to believe that two or three pieces of wire stuck against a row of hollow blocks with a light band of cement-mortar can produce a rigid, dependable beam that will stand up to rough site handling and then effectively fulfill the function of in situ shuttering, ceiling beams, etc. This is so, however, ^{Continental builders} ~~and the Italians~~ ^{incredible} ~~incorruptible~~ see nothing strange or ~~incorruptible~~ about this technique of prefabrication which is serving them so well.

It is my opinion that our own manufacturers of hollow clay blocks might try some experimentation on these lines if, in fact, they have not already done so. At the moment of writing there is one prestressing specialist firm in this country which is producing a prestressed concrete beam cored with hollow clay (and concrete) blocks - but these are factory made and very expensive. The standard clay block as made at the present time is not suitable for the site technique as described and the manufacturers would need to extrude a section more in line with that illustrated on page All that can be done with the present form of block is the kind of thing shown in the photograph on the following page where/

In addition to the prefabricated block beam the Spanish use a method of floor construction which combines prestressed concrete H-beams at one metre spacings with an arched infilling of hollow clay blocks, something like a continuous trimmer arch, springing from the lower flange of the concrete beams.

In this system of flooring a suspended ceiling is formed by utilising the short horizontal timber battens which, in the first instance, serve to support the temporary centering on which the arched course of hollow clay blocks is laid.

The blocks used for this purpose are only about 2in. in overall thickness and, as the photograph shows, they are laid flat, forming an arch with a rise of about 6 in. or rather less. The blocks are well wetted before laying and care is taken to obtain a solid cross-joint. Then after flushing/



flushing the whole of the upper surface of the arch with cement-mortar it is left to harden for a day before the next operation which is shown in this picture.

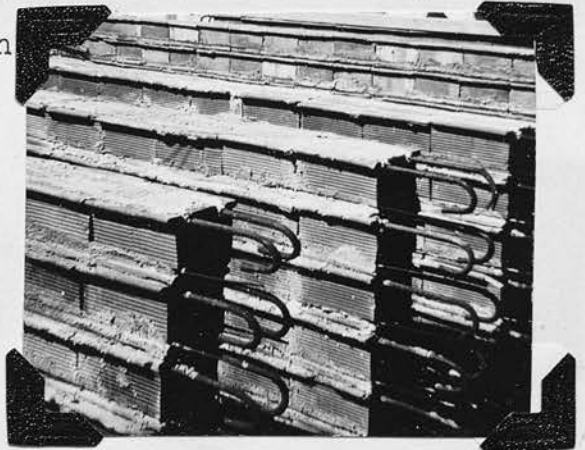
Here, the workman is simply levelling a layer of cement-mortar over a dry filling of hard-core. Afterwards the floor is screeded more accurately according to the final floor finish.

I saw this technique of floor construction applied on many different types of building in Barcelona including luxury type flats where expense seemed to be unlimited. By our standards of construction these thin supporting arches perhaps seem a little flimsy and unsuitable for anything but the lightest loadings. Yet I was assured that this method had been used for many years and that there were no failures. From any other point of view than strength I would say that this method is quick and economic of materials. It should also be a well insulated floor.



I recently carried out certain experimental work in connection with this technique of prefabricating floor beams by reinforcing butt-jointed hollow blocks, and the following account of the results gained from this laboratory work has confirmed my view that there is scope for the further development of this type of floor construction in this country.

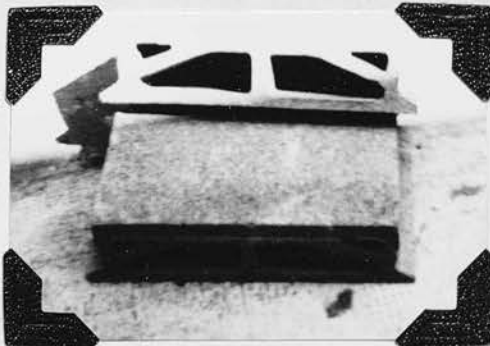
It was not possible to find a suitable hollow clay block for this full-scale experimental work. The ideal block should have recesses formed in it to accommodate the reinforcement, (this type of block is clearly shown in the photograph shown below of a stack of beams on a site at Barcelona). Alternatively there may be sideflanges formed in the block as shown in the earlier photographs. These side flanges are usually keyed or undercut to prevent the reinforcement and the containing cement from leaving the flange.



The blocks that were eventually selected for the experiments were obtained from the manufacturers of patent composite/

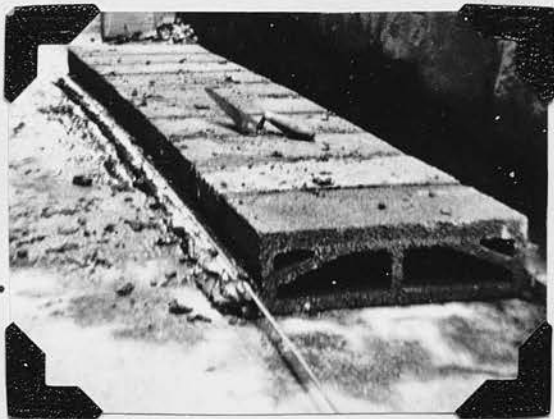
composite flooring and the section of one of these blocks is clearly seen in the uptilted block in the photograph.

These blocks were chosen because they had some sort of side flange on which to bed the reinforcing rod. Unfortunately there were no undercut recesses to assist the bonding of the reinforcement to



the blocks but for the want of a better section this type of block was used. Another more serious disadvantage inherent in this material was its weight, for the blocks were made of a dense concrete and were much heavier than the hollow clay blocks. Each of the concrete blocks weighed 33 lb. and measured 18 in. over flanges, 9 in. in width and $4\frac{1}{2}$ in. deep.

The initial beam was made up from ten blocks, cross-jointed in a mixture of Cement Fondu and sand, 1;1. The mild steel reinforcement was $\frac{3}{16}$ ths. diameter smooth wire and was bedded on to the flanges in material/



material similar to that used for the cross-joint between the blocks.

The beam was quickly made up. First the blocks were spaced out correctly and thoroughly wetted. Then the cement-mortar cross-jointing process was carefully carried out and the reinforcement pressed into a bed of soft mortar pointed on to the flange, (this stage is shown in the preceding photograph). After this the reinforcement was completely surrounded by pointing more cement-mortar around it and consolidating the whole joint with a firm pressure from the trowel.

After curing for three days a loading test was made and the beam withstood a uniformly distributed load of 862 lb. over a clear span of 6ft.1in. before the failure of the bond strength of the reinforcement. The photograph here shows the beam after failure and in the "close-up" it can be seen that the reinforcement is still intact/



intact and has simply drawn through the enclosing cement-mortar fillet. Deflections were measured during the test and were not excessive.

A second beam was then made up, this time fourteen blocks were used and the reinforcement was of the "square grip" section, $3/16$ ths.



thick. The loading was again applied uniformly over the beam which was supported over a clear span of 8ft.6in.

Failure took place immediately after the load was increased to 1500 lb. and was due to typical fracture of the reinforcement after slight elongation.

In these two tests the self weight of the first beam was 330 lb. and the second beam weighed 462 lb. These figures demonstrate the unsuitability of concrete blocks for if hollow clay blocks had been used the beams would have been little more than half the weights of the actual specimens tested. Apart from the undesirability of such excessive self weights in reducing the possible applied loads there is the difficulty of placing such heavy beams in/

in their final position. It is important that these prefabricated beams should be easily handled on the site by two men only, for anything in excess of this is usually disproportionately costly. In Spain and Italy it is quite common to see two men handling these beams in lengths up to 14ft. or so and hauling them to first floor level with ropes. On higher levels than this the beams usually travel up on a platform hoist or are hoisted by a crane.

It would be unwise to draw any final conclusions from these initial tests, for they have been only exploratory and by no means exhaustive. However it does seem that the results which have been produced so far are sufficiently encouraging to warrant further experiment. If such unsuitable concrete blocks as were used in these first trials can be made up into reinforced beams that will sustain 100 to 120 lb. per ft. super then it is fairly certain that deeper and lighter beams would safely withstand a greater range of loadings.

The advantages of these prefabricated block beams can be summed up as follows:-

- (1) The beams are quite easily made up on the site by relatively unskilled labour.

- (2) Any reasonable length of beam may be made, simply by varying the number of blocks used.

- (3)/

(3) Shuttering is unnecessary, though a single support under the centres of beams may be temporarily necessary while concreting operations are carried on.

(4) The beams may be used in suspended floors, roofs and ceilings. In floors or roofs taking normal loadings it is essential that the beams are regarded merely as fulfilling the function of built-in shuttering for the in situ concrete topping and separating rubs, adequately reinforced. In ceilings meant to support only their own weight or in certain floor or roof construction it may not be necessary for concrete and additional reinforcement in the spaces between the sides of the flanged beams, in which case a levelling fill of cement-mortar or fine concrete may be all that is required.

(5) A substantial saving in cost should result from the removal of the necessity for shuttering.

(6) The site prefabrication of the beams can be carried on by the contractor during bad weather when workmen are unable to work outdoors.

Some time after the tests were made on hollow concrete blocks a further test was applied to a beam which was made up from hollow clay blocks. The blocks were the kind usually employed in the erection of light partition walling. The photograph gives some idea of the plain rectangular section of the blocks. They are nearly 10 inches long, $9\frac{1}{2}$ in. wide and 6 in. deep; the weight of one block in a reasonably dry state is 14 lb.

The beam was made up in the same manner as the others by butt-jointing the blocks in a 1:1 mixture of sand and aluminous cement. Two $\frac{3}{16}$ ths.in. diameter wires of high tensile steel were then stuck on to the lower face of the beam by means of a $\frac{3}{8}$ ths.in. rendering of cement-mortar.



The two halves of the beam are seen - the R.H. portion is turned over and the ends of the wire reinforcement are seen protruding slightly.

After three days the beam was tested over a clear span of nearly 8 ft. and deflections measured as the loading progressed. Before failing the beam supported a total load of 1292 lb., applied uniformly over its length.

The/

The failure of the beam was due to insufficient bond strength between the cement-mortar and the reinforcement. It is probable that there was a certain amount of unevenness in the distribution of the cement-mortar around the wires, particularly where the wire rested against the face of the block. There was no significant damage to the compression flange of the beam and it is likely that an additional load could have been supported if there had been some provision in the block section for lugs to receive the reinforcement so that the wires were completely surrounded by an even thickness of cement-mortar. This, together with indented or twisted reinforcement would have improved adhesion and bond strength considerably and failure would not have occurred until the reinforcement was actually broken.

Having regard to the manifest unsuitability of such a crude form of block for this particular purpose it is clearly remarkable that an eight foot beam made up from such blocks should withstand more than $\frac{1}{2}$ ton exclusive of its own weight. This amounts to a superimposed loading of roughly 212 lb. per superficial foot.

On the next page is set out an interesting comparison/

comparison of this test result against the figures obtained in the earlier tests when hollow concrete blocks were used.

Beam Type	Self Span. Wt.	U.D.L. at Fail- ure	Type of failure	Load per ft.súp.	
				Exclusive of self wt.	Inclusive of self wt.
Hollow concrete blocks 18in. x 9in. x 4in.deep. Reinforced by two smooth M.S. rods 3/16ths.in. diameter.	330 lb.	6ft.1" 862 lb.	Bond str. failure.	95.8 lb.	138 lb.
Similar blocks but reinforced by two lengths of "square grip" or twisted mild steel reinforcement	462 lb.	8ft.6" 1500 lb.	fract- ure of rein- forcement.	118 lb.	154 lb.
10in.x 9½in. x 6in. deep hollow clay partition blocks. Rein- forced by two smooth high tensile steel wires 3/16ths in. diameter.	170 lb.	7ft.10" 1292 lb.	Bond str. failure.	215 lb.	245 lb.

The figures shown in this chart give a very high value for the beam made up from hollow clay blocks. The 6in. depth of the clay block as against the 4in. depth of the concrete blocks is, of course, responsible by reason of the increased moment of resistance following the longer lever arm, for a substantial increase in the capacity of the beam to withstand loading. But the reduction in the self weight of the clay block beam also has a decided influence \pm on the beam's loading capacity, and the beam is more easily handled on the site.

These experiments in the prefabrication of hollow block beams have suggested that there is a fruitful field of study here, for if such promising results can be obtained from very unsuitable materials which are really meant for other purposes, then it might well be possible - given the right types of beam units - to improve on the test figures already given, perhaps to the extent of an increase of 75% or more.

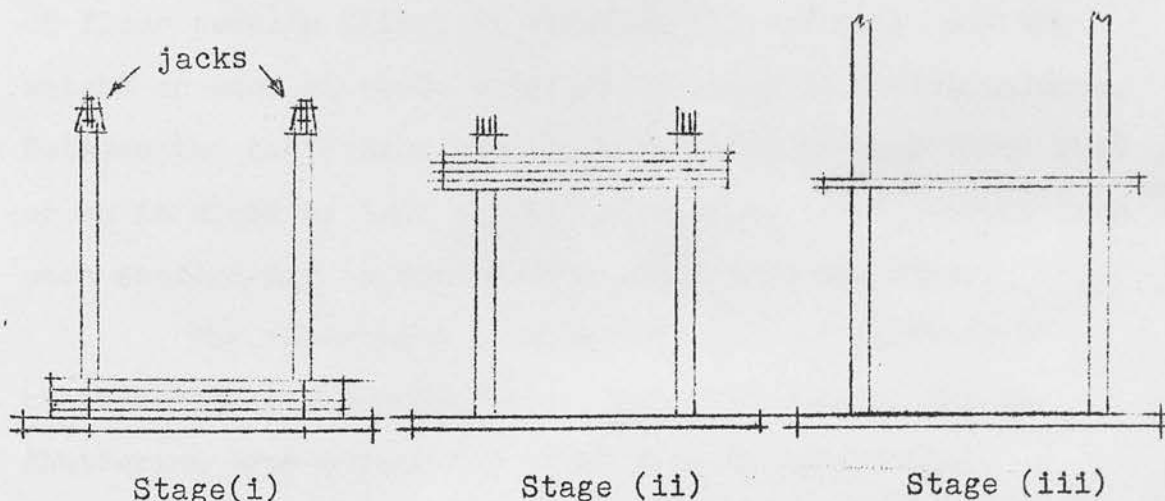
Lift-Slab Floor Construction.

The high cost of shuttering for conventional "in situ" concrete flooring and the need for a technique of construction that will help to reduce the amount of "in situ" work has exercised the minds and ingenuity of many designers. Prefabricated floor units have already been examined and it has been seen that there are certain limitations on the size of floor unit that can be cast on or off the site and be placed economically within the structure. In all probability it was this difficulty of handling large prefabricated floor units that led two Americans, Philip N. Youtz, ⁽¹⁰³⁾ an architect, and T. Slick, a business man, to the conception of their "lift-slab" system of construction, afterwards patented under the name "Youtz-Slick Lift Slab Method".

The system is based on the principle of prefabrication; all floors and roof slabs are precast, one on top of the other on the "in situ" basement slab. The simple difference between normal site prefabrication and the Youtz-Slick method is that the floor slabs are cast around the columns of the building and are thus in exactly the same vertical/

vertical plane as when they are raised to their final position. Special lifting collars cast into the slabs encircle each column and the slabs are raised by hydraulic jacks mounted on top of the columns. These jacks connect to the slabs by long threaded steel rods, passing through holes in the lifting collars.

The diagrammatic line diagram below indicates the sequence in which the slabs are raised. Stage (i) shows



the stack of prefabricated slabs at the base of the columns, in readiness for lifting. It will be seen that the columns are erected to only half their ultimate height. Stage (ii) - here the upper floors have been taken up and anchored temporarily above the first floor slab which has been fixed by/

by welding the lifting collar to the steel column. In stage (iii) the upper length of the column has been spliced on and all floors have been raised and fixed in their final positions.

During the lifting operation all jacks are very carefully synchronised through a central control panel by an operator who travels up on each slab, and the slabs are raised at the rate of 5 to 7 ft. per hour. The average size of floor section lifted is about 50 ft. by 70 ft. and the weight of each of these sections is taken by twelve columns. Between the sections a construction joint of some three feet or so in width is left so that protruding reinforcement from each section may be bonded thoroughly into the other.

The advantages in this technique of "lift-slab" construction are considerable. Obviously, the saving in shuttering over normal "in situ" work is substantial, for there is only a small amount of formwork at the edges of the slabs. Moreover, since casting takes place on the actual basement slab there is no necessity for a special casting base. The concentration of concreting, the placing of reinforcement, conduit and other services - all done so conveniently at ground level - must result in a saving/

saving in cost. The form of construction effects indirect savings too, because all the vertical walling can be regarded merely as infilling and great scope is given for light demountable partition and external curtain walling; plastering to ceilings is eliminated owing to the fine finish of the prefabricated slab. In recent American construction the only finish necessary has been a coating of plastic paint.

Bricklayers and other trades may be brought on to the site immediately the collars in the first floor are welded to the columns. This offers a great saving in time compared with the normal procedure where contractors prefer to complete all "in situ" concreting, striking of formwork, etc., before the bricklayers and other trades are brought in beneath the floor. Indeed many contractors prefer to complete the concreting and stripping to all floors before bringing in a large number of tradesmen.

Another advantage of the "lift-slab" technique is the general accessibility at each floor for all building components. There is no need, for example, to manhandle large plumbing or heating equipment through window or door openings/

openings in the external walls.

In casting a pack of floor slabs, each about 50 ft. by 70 ft., by 10 to 12 in. in thickness, and weighing upwards of 200 tons, there is the problem of separating the slabs efficiently without the expense of metal or wood formwork. In America the most satisfactory separating agent has been found to be a form of synthetic resin suspended in hydrocarbon solvents, sprayed or painted on the slab before successive slabs are cast. A further problem in this open form of construction is the lack of lateral bracing in the structure while floors are being raised for it is clear that the columns, being restrained at their base only, will act as free cantilevers, and lateral wind forces on partially erected floor slabs will impose critical bending stresses on the column bases. In addition to this, complex flexure may be set up in the columns due to the axial end loading of the jacks plus distortion of floor slabs. To solve this problem it has been found necessary to erect the columns in two stages, the jacks being mounted at the end of the first half of the column and one or more floors welded in position with the rest of the slabs restrained provisionally at the upper end of the column.

This/

This was done when "lift-slab" construction was applied to a seven-storey block of flats at Calvary, Canada. The building was 64 ft. high, the highest ever attempted using the "lift-slab" method, and apart from the danger of lateral wind force the slenderness ratio of the columns was such that they would scarcely sustain the full loading transmitted by the jacks. In this instance the columns were erected in two lifts, the initial lift being 42 ft., then 24 ft. The splicing of the columns was carried out by welding in order to preserve the continuity of the section.

The "lift-slab" system of construction is being operated by eleven American and four Canadian firms under licence to a Lift-Slab Corporation which has acquired all patent rights. Comparative costs have been carefully worked out for a number of schemes, for example, on the construction of the Trinity University administration building the "lift-slab" technique saved at least 10% and it was estimated that the structural portion of the Calvary building cost ⁽¹⁰⁴⁾ 30% less than if it had been constructed by normal structural methods.

It appears then, that this quite sensational method of construction has the merit of economy, and it would/

would indeed be interesting to see this technique applied to suitable buildings in Britain. If this should prove possible, then full collaboration between architect and engineer is essential, because the ideal structural layout for "lift-slab" construction is likely to impose an unwelcome discipline on the architect's design.

The floor layout has to be designed so that the column spacing, while at the greatest possible distances, keeps the floor slab construction within safe deflection limits. Moreover, the column spacing must be such that the capacity of the lifting equipment on each column is not exceeded, and this limitation is of the order of about 50 tons per column. Again, there is a limit to the number of jacks that can be operated from one control panel, thus the maximum number of columns to a complete slab is governed by this.

As in most buildings, deflection of the structure has to be kept down, and in certain American buildings employing the lift-slab method, special measures were adopted in fixing vertical walling so that allowance was made for vertical movement of the floor slab. Also, with such large areas of slab the possibility of thermal movement has to be carefully considered and due allowances made for it.

Pumped Concrete.

In floor construction, particularly in multi-storey buildings, the cost of transporting concrete from mixer to placing point is usually very considerable, involving a hoist or crane delivery to the floor under construction. It is often difficult to plan the sequence of delivery so that the mixer can work at its maximum capacity, for the chain of operations - the hoist or crane - the waiting barrows - is a complicated process and delays of only a few minutes can add up during a day and make all the difference to concreting costs.

The use of pumped concrete has done much to meet this difficulty of suiting the placing of the concrete to the output of the mixer, for by this method the concrete is conveyed directly from mixer to the point of use via a pipeline that dispenses with hoists or cranes and often delivers direct to the shuttering without intermediate transportation by barrow.

The early method of forcing concrete through the delivery pipe was by ram pump or by a worm screw, but a more recent development has been the compressed air method of moving the concrete along the pipeline. By this method it has been found possible to pump concrete to heights in excess/

excess of 100 ft. and to a horizontal length of at least 1,000 ft. (105)

The delivery pipe is 6 in. diameter and is in steel tubing in 10 ft. sections together with smaller lengths and a variety of bends to obtain any specific length or direction. The sections are coupled together with a patent coupling which is completely airtight and is quickly and easily connected or disconnected.

Simply stated, the system consists of the pipeline, a delivery hopper, and at the mixer end there is a pressure cylinder in which the air propulsion is applied to the concrete. The concrete is discharged into the pressure cylinder, which is then closed by a cone-type valve. This has a pneumatic surface cleaning attachment which keeps the air sealing surfaces clean. Compressed air, stored in an air receiver is directed into the top of the pressure cylinder by operating a "pull-down" release valve. The air pressure then forces the whole of the batch of concrete along the pipeline at a speed controlled by the adjustment of the air pressure in the cylinder.

The pipeline is full of concrete during the working period and the effect of forcing in a batch of fresh concrete is to cause the same volume of concrete to be ejected from the delivery end of the pipeline. This means that/

that the concrete moves through the pipeline in a series of impulses, yet because the pipeline is constantly full there is no segregation of the concrete aggregate and from cube tests taken of concrete at the mixer and delivery end it has been proved that there is no variation in the strength of the concrete.

This type of pumping equipment was used on the new premises for Marks and Spencer in Princes St., Edinburgh. Pneumatic placing of concrete was favoured in this particular instance because the site was extremely small and congested owing to the necessity for completing the rear portion of the building before demolishing a hotel at the front which had to be kept continuously in use. Another factor favouring pumping was the necessity for constructing foundations and retaining walls underneath the existing hotel building, and this meant long stretches of tunnelled trenching, not easily accessible by barrow.

The mixer was set up in the basement at the rear of the building and the first use of the pump was for the five floors in the rear portion. It was soon discovered that there was a technique to be mastered in using the pump efficiently and a considerable amount of experiment with gradings and mixes was carried on over a period/

period of weeks before satisfactory results were obtained. At first it was found that the compressed air blew right through the wet mixes and then when stiffer mixes were put into the pressure cylinder the friction of the dry concrete against the sides of the pipeline caused seizing up and blockages.

Generally it has been found that slumps between 2in. and 6in. are suitable for the concrete to be forced to maximum distance and height. The grading of the concrete was most suitable for pumping when sieve analyses for the all-in aggregates conformed to a regular curve. The concrete was delivered to a hopper feeding into barrows at floor level and a little trouble was experienced from time to time in preventing blockages in the neck of the hopper. The photograph on the next page shows a workman clearing the hopper during concreting operations on the Marks and Spencer site in Edinburgh. The pipeline appears in the picture at top left centre and is delivering concrete up to a floor approximately 70 ft. above the level of the mixer.

To achieve the desired economies with pneumatic placing it is essential that careful planning is made of the sequence of operations so that the pipeline may be moved as,

as little as possible. The pipe couplings are quickly made ^{pipes} or disconnected, but the /have to be supported and held firmly, particularly where the concrete is forced around bends, and valuable time is wasted on couplings and supports, etc. when the pipeline is moved to a fresh position.



Although the pipeline requires support at intervals it can cross spaces between formwork and scaffolding that would otherwise be an obstacle to the passage of barrows and workmen. Difficult ground conditions, so common to building sites, are more likely to permit the passage of a six inch pipeline than the clear and level space essential for a barrow-run.

ROOFS.

The construction of roofs on domestic buildings was, until a few years ago, confined almost entirely to tiles or slates carried on softwood rafters supported by purlins or other timbers. Since the war the shortage of softwood due to restricted imports and controls, together with almost prohibitive levels of cost, have encouraged the development of substitute materials such as reinforced concrete beams with composite coverings, but more particularly this change in the availability of softwood has encouraged the methodical design of modern timber roof construction so that timber sizes have been more accurately and realistically calculated for the particular type of roof covering.

These changes in roofing technique designed to cut down timber sizes had a particular application in Scotland, for traditional methods incorporating 5 in. by 2 in. to 7 in. by 2 in. rafters, each separately supported by sturdy struts and collars, were universally employed irrespective of the load-bearing function of the particular roof when, in England, the 3 in. by 2 in. rafter on one or two purlins according to span, had been commonly used for years prior to the last war. Scottish timber sizes were always more substantial than those employed in English construction, mainly because the Scottish (Ballachulish) slate on close-boarded sarking was so much heavier/

heavier than the Welsh slate and lath construction so common in England.

Changes in roofing technique in Scotland have come about very slowly, even though the production and use of the heavy Scottish slates has virtually ceased. The Scottish contractors seem reluctant to accept the evidence available to them in the South that comparatively light roofing timbers are capable of supporting modern roof loadings. This is yet another example of the tendency in the building industry for contractors to cling to the old forms of building and to "err on the safe side" with timber sizes rather than acquire and apply a rudimentary knowledge of mechanics in the design of their roofing timbers for specific loadings.

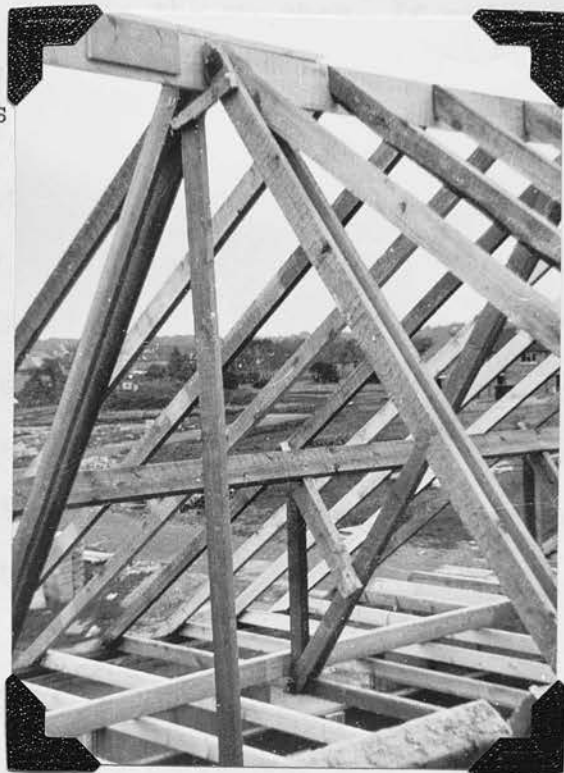
The larger Scottish firms specialising in extensive schemes of two-storey house-building have, to a large extent shaken off the ties of tradition in their roof construction. Most firms use a trussed rafter structure made up from timbers all pre-cut to size, the trusses being assembled on a jig at ground level on the site or half-trusses being made up in the workshop.

The trusses may be spaced out at about 6 ft. intervals as shown in the photograph on the next page, with propped purlins running through and supporting intermediate rafters/

rafters of comparatively light section, perhaps as small as 3 in. by 1½ in. or even 3 in by 1 in.

Alternatively the trusses may be spaced at 18 in. centres and used without purlins; whichever method is adopted the aim is usually to effect a saving in timber and also to produce a roof which is independent of support from intermediate load-bearing partition walls.

Close-boarded sarking with slates nailed directly to it has always been favoured in Scottish roof construction and is still employed on many roofs where strict economy is not the prime consideration. On large municipal housing schemes in the Edinburgh area there is a tendency to use one or other of the proprietary insulation boards instead of close-boarded sarking; a final covering of concrete tiles is hung on horizontal tile-lath nailed through the insulation board to the rafters. This form of sarking is probably/



probably much better than the timber sarking with butt joints, for it is more continuous over the roof and the effect of thermal insulation is improved considerably.

The main point of criticism in such a roof is the dependence on the tiles to exclude the weather. If rain or fine driven snow should penetrate beyond the tiles there is no other defence against it, for the rain or snow will come to rest on the horizontal lath and before long it will soak through and drip on to the ceiling below. The conclusion to be drawn from this is, of course, that close sarking of any kind should be protected by a bituminous felt covering together with a proper system of counter-lathing to ensure that rain or snow finding its way into the roof can escape harmlessly via the felt to the roof gutter at the eaves.

But the provision of sarking, felt and counter-lathing is an expensive business and hardly likely to be economically justifiable in low-cost housing work. In my view, the most economic and reasonably efficient treatment under tiles or slates is the simple application of a weather-lapped covering of bituminous felt applied directly to the rafters, with tiles or slates fixed to horizontal lath nailed through to the rafters. The felt must be well lapped and carried down and through to the eaves gutter, so that rain and melted snow penetrating through to the sarking can escape. /

escape.

Such a treatment under the external roof covering provides that second line of defence not usually provided by ordinary sarking methods and the degree of thermal insulation is quite reasonable. Most important, the cost is lower than practically any other form of sarking under tiles or slates.

Apart from the use of trussed rafter units coupled with light-sectioned intermediate rafters, it would seem that there is little more that can be done to lower the cost of this traditional type of pitched roof, though some saving has been realised by building the complete roof on the ground and lifting it in one piece on to its final position with the aid of a powerful crane. There has, however, been a tendency ^{towards the use of} ~~to investigate the effect of new forms of roofing,~~ particularly the mono-pitched form of roof, sometimes called the pent-roof. There are indeed, strong claims for economy based on this form of roofing, for apart from the obvious reduction of the wasteful space and material associated with the conventional pitched roof, the mono-pitched roof, like the flat roof, can be adjusted to suit any plan of building, however irregular. It can also give good overhangs at doorways or wherever else they may be needed, and great scope is given to exploit modern forms of roof construction such as strawboard and other coverings on beams.

I experimented with this form of roof on a house that I recently built for myself and the photographs give some indication of the adaptability of the roof to an irregular plan. If, in this case, the roof had been of a conventional type it would have been necessary to form at least four valleys together with seven hips, instead, the mono-pitch roof is simply returned around the several breaks in the plan outline. Porches at the front and rear entrances are quite easily formed by cantilevering the roof bearers for the requisite distance beyond the wall face. In this example the roof serves as ceiling also and the line of slope is expressed in the ceiling. The construction of roof and ceiling is very simple; 6 in. by 3.in. softwood beams at 4 ft. centres support 2 in. thick strawboard slabs, and a three-layer built-up bituminous felt roof ensures weather resistance.

The ceiling beams are exposed and the underside of the strawboard is ready for decoration/



decoration immediately after fixing.

Taking the saving in ceiling construction along with the savings resulting from the reduction of softwood, tiles or slates, labour, etc., the mono-pitch roof can compare very favourably against traditional roof construction on the score of cost. Thermal insulation is quite good where a 2 in. minimum thickness of wood-wool, strawboard or other similar covering is used; my own experience of this particular roof is that the thermal insulation is far better than the normal pitched construction where a thin plaster or plaster-board ceiling allows heat to escape through it to the cold air in the roof space.

The mono-pitch roof can be criticised on a number of points however; for example the impact of heavy rainfall or hail can be heard quite clearly, even through 2 in. of strawboard. Also it is very difficult with such a roof to find a suitable place for the water supply tank in order that a sufficient head of water is available for sprays and other services. Some architects have built the tank into the main chimney stack, well above the roof level, but the frost hazard is something that must be reckoned with in such an exposed position, even when the tank is theoretically kept warm by the passage of adjacent flue gases.

Houses/

Houses recently built in the new towns of Harlow, Glenrothes and others have frequently featured these pent or mono-pitch roofs but in practically all cases a separate and level ceiling has been insisted upon, presumably because the responsible authorities thought sloping ceilings might be regarded as a little odd, and therefore unpopular with the general run of tenants. This point of view is understandable but unfortunate, for the provision of additional timbers, etc. to support a separate ceiling will run up the cost and thus defeat the very purpose of this new and cost saving technique of roof construction.

It is noticeable however, that many of the designs prepared by architects of homes for their own occupation or for competitions do, in fact, include flat or mono-pitch roofs as a feature of the design, usually incorporating the ceiling as an integral part (the underside) of the roof. Indeed the principle of the pent-roof is sound from the planning standpoint; as exemplified by the house shown in the photographs on the preceding page, where the roof slopes upwards towards the sun and a fine view of the Pentland Hills. The windows and ceilings reach high to the sun and the view, and the less important rooms are grouped on the rear or low side of the house. This type of roof is also well suited to a steeply

steeply sloping site. The photograph below illustrates how sharp differences in site levels can be exploited by planning living space in what would otherwise be wasteful under-building; additional ceiling height in the forward lower storeys can be realised by the use of the mono-pitch roof, inasmuch that the forward upper floor levels can be raised in relation to the main floor level in the rear part of the house.

It should be quite easy to introduce prefabrication methods in connection with this kind of roof, particularly on sites where there is a high-lift crane with the capacity to place large sections of roof at each lift. The sections could be factory made, complete in every respect, including roof covering and ceiling finish. Even the gutter



brackets could be fixed before the roof sections left the factory, and gutter or rhone simply dropped into place on the site. The disposal of rainwater from the mono-pitch roof is a very simple matter compared with the traditional roof. In the house shown above there is just one straight length of r.w.gutter, about 40 ft. long, fixed at the rear and draining more than 1000 ft. super of roof.

The development of shell membrane concrete has made it possible to roof over large areas with an exceptionally thin skin of concrete. These roofs are either barrel-shaped or domed and the minimum thickness of concrete is in many instances no greater than two inches. As a consequence of this the saving in material and dead weight is tremendous when a roof of this type is used. An example recently quoted in the technical press stated that the Dome of St. Peter's in Rome, which is 131ft. in diameter, has a total weight of 10,000 tons, while the shell concrete domes on a market hall in Leipzig are each 248ft. in diameter but weigh only 2,160 tons. ⁽¹⁰⁶⁾

The maximum economy of the shell membrane is only realised when large spans are to be roofed over such as hangars, markets, assembly halls or the like, where obstructing columns or other supports are not wanted. These conditions are seldom encountered in housing work and at first sight it would seem useless to consider the use of these shell roofs in connection with house-building. Moreover the barrel-shaped or domed roof, if applied to housing, would need a flat ceiling, the provision of which would be costly and would defeat the economic intention of the shell roof/

roof which seeks to provide its own ceiling finish in the actual underside of the concrete membrane. Clearly, this domed ceiling may well be acceptable in markets, warehouses, factories, etc. but there would be some appreciable difficulty in persuading the ordinary person to accept such curved ceilings in his upper rooms , even if the thin shell could be adequately insulated.

Yet I feel that the average person's preference for a flat ceiling is something that could be overcome provided it was clearly shown that a substantial cash saving was realised when a shell concrete roof was employed. It does not seem impossible to design a barrel-shaped roof, spanning from cross-wall to cross-wall with bedrooms arranged so that the ceilings were as symmetrical as possible, particularly in the larger and more important rooms.

The thermal insulation of such a thin shell could possibly be incorporated between the concrete upper surface and the final bituminous covering and if this did not also take care of condensation then an appropriate dressing could be gunned on to the underside of the shell. It should not be difficult to improve on the "U" value for the average roof and ceiling construction on low-cost terraced housing.

PLUMBING INSTALLATIONS

In many ways, plumbing installations are akin to a modern engineering production, consisting of systems of pipes in lead, copper and iron connecting to tanks, radiators, sanitary fittings, etc., yet we find that the traditional craft techniques together with site assembly methods are still being employed on repetitive work such as housing, throughout the building industry. A little progress has been made since the war in reducing the number of varieties of plumbing fixtures and fittings, and the general adoption of copper piping with its improved jointing techniques has helped a little to reduce site man-hours. But there are many plumbing processes that should be done in the workshop or factory, where working conditions are far better suited to such work.

Plumbing contractors cannot always be blamed for failing to appreciate the economy in a system embracing the maximum amount of off-site labour, for it is seldom that a small house type is designed for an economic plumbing system. A further deterrent to economic plumbing design is the uncompromising attitude of so many local authorities towards any change of any kind from the known and proved methods that have been successfully employed in the past.

How/

How often is one told, when remonstrating with a local authority official over a particularly stringent requirement, that " we prefer to err on the safe side". This is all very well, but so many authorities place different interpretations on the margin of safety.

It would seem that there are two ways in which plumbing installations in house-building can be designed to save cost, (1) by almost 100% prefabrication in the workshop or factory, and (2) by the prefabrication of selected elements of the complete plumbing unit so that an economic balance of site work and factory work can be attained.

If complete prefabrication is to be adopted, the first requirement is that the house must be designed for it and the local authority must be prepared to permit a compact system that involves a "single stack" system into which all wastes can go, also there must be a considerable relaxation in the requirements for cold supply tank sizes, and expansion pipes must be allowed to empty into that tank and not go trailing through cold roof spaces to the colder outer air.

Plumbing "panels" housing compact systems of pipes, jointed and fitted ready to receive the sanitary fitments have been produced in America for a number of years, and in Germany a unit known as "Vica" ⁽¹⁰⁷⁾ has been produced and consists of/

of a prefabricated, self supporting double frame of steel sheeting, carrying gas as well as hot and cold water services and drains. All the piping is accessible from a duct which is like a small cupboard, planned between the fitments in the bathroom and those in the kitchen.

In this photograph is seen a prefabricated plumbing "panel" being fitted in place in a large block of experimental flats in Milan. The pipes are housed in a welded frame of angle iron and the frame is built-in to a partition wall between the bathroom and small recess off the entrance space.



This panel provides connections for the bath, washbasin, w.c. and a bidet. The design of the flats did not, unfortunately, allow for a link with the kitchen fitments and these were piped by ordinary methods. A few of the "panels" were made up in hard plastic pipe as an experiment.

~~The French have produced some interesting examples of prefabricated/~~

Many authorities on plumbing matters are loath to accept the principle of total prefabrication and argue that the installation of a necessarily bulky mass of concentrated pipework may well take more site man-hours than fixing separate units of pipework. There certainly appears to be a body of opinion in favour of the second method mentioned at the beginning of this commentary on plumbing systems - the prefabrication of selected elements of the complete plumbing unit so that an economic balance of site work and factory work can be attained.

Here again it is essential that the building is designed to accommodate a compact plumbing system, with all pipe runs cut down to a minimum. The house plan, so far as the plumbing layout is concerned, must be sufficiently repetitive to justify the extensive planning preliminaries so essential to off-site assembly and prefabrication. The plumbing installation must be laid out in detail on the drawing board and so accurately that bends, couplings, lengths of pipe, etc., can be measured from the drawing. As an alternative to this a "mock up" of the installation can be made up on the site and subsequent measurements taken from it. It would probably be more satisfactory to do this because the average domestic building/

building has an excessively high dimensional variation and tolerances for this variation would need to be considered in the off-site work.

The very fact of having to admit the necessity for a prototype to be made up after the first of a series of houses is erected emphasises the serious difficulty of dimensional variation in building work of practically all types. The lack of modular co-ordination in the design and the absence of precision in the execution of the design on the site - these are the obstacles to successful pre-assembling and prefabrication, for the construction of a first house in a large scheme takes time, and it is not often possible to go forward with a single house - usually they will be in units of four at least.

Clearly, if factory methods of pre-assembling parts of plumbing systems are to be used, precise requirements must be known well before the actual construction starts, so that the necessary "tooling up" can be done and production of the assemblies well on the way. A substantial margin of time between workshop production and site installation is always a prudent insurance against raw materials or labour difficulties. It follows from this that preplanning of plumbing assemblies is essential to early delivery dates and this preplanning can only work if building tolerances are drastically/

drastically reduced to the extent that the finished building does not vary more than $+\frac{1}{2}$ in. or $-\frac{1}{2}$ in. from the detailed drawings.

Several years ago the Lead Technical Information Bureau arranged for a time and motion study ⁽¹⁰⁹⁾ to be made of plumbing processes incorporating "off-site preparation" methods wherever possible in the building of a group of three-bedroom houses. The plumbing installation in these houses followed the usual pattern - kitchen sink, bath and basin in bathroom, separate w.c., normal domestic hot-water system, all wastes discharging into the soil pipe and each waste vented. It was found that there was a great deal of unproductive planning time on the site, when the individual plumber had to stand and consider what he needed for the particular job in hand and to make up his mind on the best approach to the job. This waste of time did not occur on the one house in the group which had been selected for the incorporation of "off-site preparation" methods, nor was there any difficulty over the availability of the various plumbing components for they were all ordered well in advance of requirements.

In the houses featuring ordinary site methods it was noted that certain components were found to be difficult to obtain during the course of the work with the result that costly, complicated substitutes had to be used in order to/

to avoid even more costly delays. Other interesting points in the report on this study included the conclusion that cost control was facilitated by the predetermination of labour times and material requirements. Bonus assessment was far more accurate and the routine processes of assembly permitted a closer check on inefficient work.

As was to be expected in an investigation initiated by the Technical Information Bureau of the Lead Industries Development Council, all cold supply and distribution pipes were in lead and the main soil stack was made up from cast lead standard lengths with all waste pipes in lead also. It was claimed that when the pipe material used is lead it is possible to gain or to lose more than the normal building tolerances by hand manipulation when positioning and fixing the assemblies. This is quite a fair statement, for such a ductile material as lead piping is more suited to such assemblies than, for example, copper or iron piping.

If only the advocates of lead piping could produce a simple joint of good appearance to compete with the many excellent copper pipe joints on the market, there might be an opportunity for lead pipe to regain its lost position in domestic plumbing systems. I understand that efforts are being made to produce a suitable joint that will replace the familiar bulbous wiped joint so beloved of plumbers.

Bathroom and kitchen costs in any house could be effectively reduced if enough of their dimensions were standardised and coordinated to permit prefabrication on a very large scale. If a module of say, 32 in. was to be firmly adopted by all designers, together with an 8 ft. ceiling then manufacturers might be encouraged to produce storey-height panels, faced up in porcelain enamel or stove enamel, containing pipe runs, wastes fittings, etc., within the panels.

One 32 in. panel would accommodate the end of a standard bath and two panels would make up the length of it. Single panels would likewise do for the washbasin and for the w.c.pan. This 32 in. module might be rather narrow for a doorway unless it was kept down to take a 28 in. door, but a suitable and sufficient window could be arranged in a single panel. The minimum sized bathroom would therefore work out at three panels by two, or 8 ft. by 5 ft. 4 in., and larger rooms could be obtained simply by inserting additional panels in the walls. In the kitchen a 32 in. module should suit sink, tub, washing machine, cabinets, etc., and the window could be the width of a single or double panel as required.

With such a system of modular coordination it should/

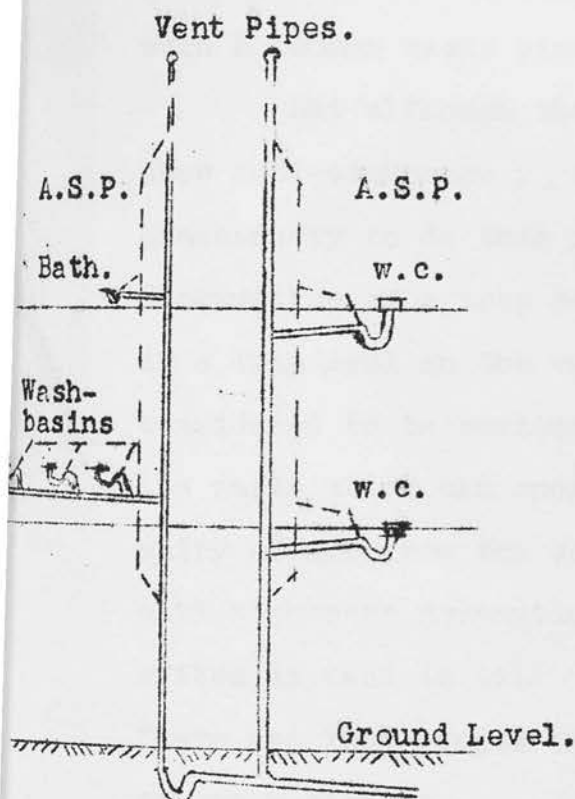
should be possible for an architect to specify a size or type number for the particular bathroom or kitchen desired. The range might, for example, extend from 1 to 8, with a No. 1 set of panels for the very small low-cost house and a No. 8 for the larger and more expensive design. There could be "right-hand" and "left-hand" models, according to the position of the door in relation to the window, and altogether this ought to provide a sufficient variety of types to suit anyone who is prepared to sacrifice a little individuality in his bathroom and kitchen layout in order to save himself money.

Standardised ceiling panels on the same module could be prefabricated and in these panels it ought to be possible to incorporate pre-assembled lighting and heating units. On the more expensive panel sets it might also be possible to incorporate an extract fan for ventilation purposes. The ceiling panels would be finished in a similar manner to the wall panels.

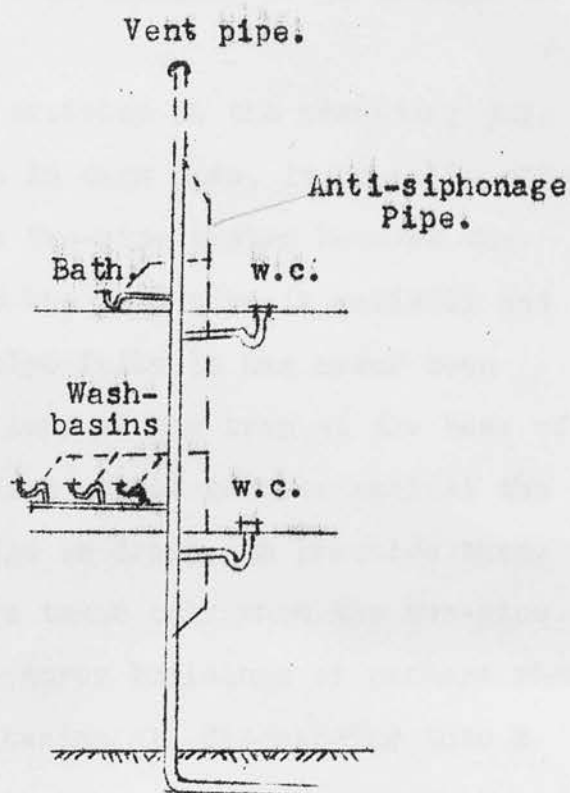
The tooling up and equipment of factories to start the production of modular plumbing panels in line with these suggestions would be extremely costly in the first instance, and manufacturers would require convincing proof of the general intention of designers to provide for factory-made plumbing panels in the majority of new houses and the good will of the industry including the plumbing unions with regard to the installation of the panels.

Traditional Plumbing Layouts and the Single Stack System.

Two-pipe System.



One-pipe System.



The one-pipe system of drainage was introduced into this country between the wars in an endeavour to reduce costs by providing one main pipe to take all wastes from baths, wash-basins, sinks, w.c.'s, urinals, etc. It is clear from the sketches that the one-pipe system eliminates a substantial amount of piping and results in a much more simple and labour-saving layout, moreover it is claimed that the alkaline nature of the soapy wastes have a neutralising effect/

effect on the acid soil wastes. Certainly the flushing action of baths and washbasins is bound to be of benefit in such a common waste pipe.

But although the two sketches on the preceding page show anti-siphonage provision in each case, it is quite often unnecessary to do this in the two-pipe system because the destruction of a trap seal in the soil pipe is unlikely and if a trap seal in the waste pipe fails it has never been considered to be serious, so long as the trap at the base of the waste stack can operate as a second barrier against the entry of air from the soil pipe or drain. In practice then, anti-siphonage precautions are taken only when the two-pipe system is used in tall multi-storey buildings or perhaps when there are long ranges of washbasins, all discharging into a common wastepipe.

In the one-pipe system however, it has always been considered absolutely essential to require an efficient anti-siphonage installation to prevent air pressure or suction destroying trap seals and so allowing air from the common wastepipe to escape into the interior of the building.

It follows from this that the one-pipe system may not always be cheaper than the two-pipe layout, for the provision of a second system of piping for anti-siphonage purposes/

purposes in all one-pipe installations, large or small, is quite costly. Added to this, it is usual to insist on special deep-seal traps on all sanitary fittings, and this causes the cost to mount still higher.

A recent comparison of costs by the Building Research Station (110) gave £206 for the two-pipe system and £171 for the one-pipe system in a five-storey block of flats. This showed a saving of only about £7 per flat and it was said that the saving is often less than that.

Experiments directed towards the further simplification of the one-pipe system have been going on in the B.R.S. for the past five years and the final result of this research is that the one-pipe system as shown in the beginning of these notes can, subject to certain conditions, operate quite successfully without any anti-siphonage installation and without special deep-seal traps. It has been found by experiment that in conventional one-pipe and two-pipe systems, the maximum seal loss that can occur in normal use is about one-eighth of an inch, which is, of course, a negligible amount. On the other hand, in single-stack systems (i.e. without anti-siphonage pipes) it has been found that washbasin self-siphonage may be excessive if the wastepipe is too long, and it has been calculated that the maximum length/

length of the wastepipe should be 3 ft. ^{to 5ft.6in.} in order to ensure that an adequate water seal is retained, and at the same time there are additional requirements for the slope of the wastepipes to guard against excessive velocity in the draw-off from washbasin or sink. Little trouble is experienced with bath wastes or large sinks because it has been found that the seal in the traps to these appliances is usually maintained by the last dribble of water as it passes over the relatively greater length of the fitment.

The experiments made by the B.R.S. in support of the "single stack" system of drainage have been most extensive and have included the erection of a full-size four-storey installation built up from transparent Perspex piping in the Parkes Museum of the Royal Sanitary Institute. Apart from this, laboratory experiments with a 4 in. cast iron stack, 60 ft. high have been made and during the last four years, trial installations have been incorporated in certain of the new multi-storey housing schemes of the London County Council, and the data obtained from these experiments and trials have confirmed that "single stack" installations are quite adequate provided that certain simple design rules are observed. It would seem, from all this, that a great deal of unnecessary installed, plumbing work has been /and is still being installed in modern building work.

Single-stack plumbing can do much to reduce housing costs, but only if local authorities, plumbing contractors and architects accept the evidence of this revolutionary experiment. The Scottish local authorities have taken a lively interest in these new developments and quite a few city and burgh engineers have been down to Queen Anne's Mansions to see the Royal Sanitary Institute's exhibition of single-stack plumbing. In Edinburgh the system has already been employed in the Gorgie Flats housing scheme and the Chief of the Drainage Dept. (who has seen the single-stack experiment and is a convert to it) is prepared to give a sympathetic reception to private schemes featuring this modern method of waste disposal. And this, in the capital city of Scotland represents progress of a most encouraging kind towards the rationalisation of plumbing standards, for there is little doubt that in Scotland, the general standard of plumbing workmanship is in advance of the standard obtained anywhere else in Great Britain with perhaps, the sole exception of metropolitan London.

This high quality of plumbing work is all very well, so long as it is confined to the aspects of plumbing which really affect the health of human beings. But my own feeling is that too many individual standards in plumbing are linked with/



A Typical Elevation "back of "
Princes Street, Edinburgh.

with old fashioned customs that are plainly out of touch with modern methods based on indisputable scientific data.

Take, for example, the general Scottish local authority requirements for the venting of plumbing and drainage systems. Every separate soil pipe has to continue up and serve as a vent pipe, bath and basin wastes emptying into a separate waste pipe are deemed to need a continued vent also. The result is that the walls of Scottish houses are literally festooned with ugly and expensive external cast-iron pipes, breaking through the eaves, the most vulnerable part of the roof, or hung out via an offset or a swan-neck. Such an outright waste of building material and plumbing craftsmanship could hardly be imagined, yet it is going on now - everywhere, almost, in Scotland. There may be a few cases where long waste pipes from lavatory basins are prone to emptying traps through self-siphonage and where the separate ventilation provision is necessary, but these surely represent only a very small minority against the total number of plumbing systems which, by all the recorded facts, will never incur the dangers of broken trap-seals.

Again, the recorded facts suggest that this danger resulting from a broken trap-seal has, for a very long time been over-rated. Exhaustive research has been carried out concerning the effect of drain or sewer air on animals and/

and the results of this research appear to rule out the possibility of harmful effects from the inhalation of drain or sewer air escaping past inefficient plumbing appliances. There is, in fact, no evidence to suggest that the drain air has any toxic effect on human beings.

The provision of one high vent at the head of a sewer or drain should suffice for six or more houses, I have frequently seen this done on terraced houses in England without any complaint from occupiers. Yet compare this against six Scottish houses with the minimum of two vent pipes to each house (one 4 inch soil vent and one $2\frac{1}{2}$ in. waste vent). If each ventpipe is taken to be an extension of the soil or waste connection then the minimum length of pipe needed to take the vent beyond eaves level will be 10ft. or thereabouts. So, for the six houses some 60 ft. or 10 six ft. lengths of 4 in. cast iron heavy gauge pipe are required, thus entailing 50 ft. more pipe than is really necessary and at an additional cost amounting to £20 or £25.

This calculation has only taken account of the additional soil vents, for with the normal Scottish system of combined drainage it is not possible to group soil ventilation with the ventilation of wastepipes. In this system the waste pipes are usually grouped so that they and the rainwater pipes are/

are separated from the soil drain by an underground trap. The waste pipe thus serves the purpose of keeping the seal in the trap intact during long dry spells, and this is probably better than the English method depending on trapped gulleys below all rainwater fall-pipes, but there isⁱⁿ the Scottish method a distinct disadvantage in incorporating traps indiscriminately in underground systems of drainage, for there is usually no access to the trap other than perhaps some provision for passing a "plunger" down a vertical branch taken from the trap.

Coming back to the question of ventilating the waste pipes, it would appear then, that if there is to be a trap seal in the drain a short distance from the entry of the waste water into that drain, there is very little of the waste pipe and its drain to ventilate. In fact, ^{that} all/the waste pipe vent can be said to be doing is that it is acting as an insurance or safeguard against the self-siphonage of the traps under the sanitary fitments or the underground trap in the drain. It is very unlikely indeed that a 4 in. diameter underground trap will ever have its seal broken by siphonage, and if the wastepipes from washbasins are fixed in accordance with the elementary rules mentioned earlier in these notes on single-stack systems then the continuation of the waste-pipe/

pipe beyond the eaves is clearly a waste of scarce material, a waste of plumbing manhours and a waste of the client's money, not to mention the harmful effect these vent-pipes usually have on the appearance of a well designed building.

The manufacturers of cast iron fittings have been alive to the possibilities of single-stack plumbing and have already available on the market a very comprehensive range of fittings designed to suit this new system. One of the more recent additions to the range is bossed piping where pipes of various lengths are supplied with screwed bosses to receive bath, sink and washbasin waste pipes. These are quite neat and serviceable joints but considerable care is needed in ordering the bossed fittings to ensure that the bosses are present at the desired height and angle to suit the position of the particular sanitary fittings. Some firms have specialised in the manufacture of multi-branch fittings for single-stack systems in steel tube or in copper. On steel stacks, the waste inlet bosses are normally tapped with the appropriate thread and supplied with special non-conducting copper to iron connectors. The copper stacks have patent joints brazed to them to receive the waste pipe connections.

The spun pipe does not appear to have been generally accepted in Scotland in spite of the obvious advantages/

advantages of this comparatively new material, which presents a pipe which is of unvarying thickness and is, in fact, precision made. This centrifugal method of casting spins the metal outwards against a containing mould so that the resultant pipe has a smooth internal surface and is completely concentric; in addition to this the centrifugal force compacts the metal and there is, in consequence, a complete absence of sand holes and joints. A further advantage is that the pipes are made without ears, and when these are required they are supplied separately, with the result that the fixing of the pipes to the wall is easier owing to the adaptability of the movable ears which move up or down to suit the position of the nearest joint in the brickwork.

Turning to the consideration of sanitary fitments in low-cost housing, the basic requirements for a normal household are a bath, washbasin, sink and w.c.. Usually the w.c. is grouped in the bathroom along with the other fitments, with the result that three people may desire access to one room for three quite different purposes. The excuse put forward for this kind of planning is usually based on the cost aspect, but it does seem unfortunate that, failing a completely separate w.c., the designers of cheap homes cannot arrange even a partial screen between the w.c. and the other fitments so that/

that adult members of a family and their children can use this all important room to better advantage, though without complete separation.

A useful bath has recently been designed which has an overall length of only 5 ft. and yet is only 3 in. short in internal length than the majority of baths which are 5 ft. 9 in. or more in overall length. This saving in length has been achieved by placing the taps on the side of the bath at the waste end. This arrangement is far handier for the bather and is also much more convenient for the plumber who is able to make his connections much more easily than if they were in the usual place at the end of the bath. The bath is designed to take a combined waste and overflow fitting and the underside of the roll of the bath is arranged to take a panel without providing a special framing for it. Thus, fixing time for this type of bath is reduced substantially and another point is that although the depth of the bath is $1\frac{1}{2}$ in. less than the standard depth, the actual water depth is not below standard because the height of the overflow is compensatingly increased.

Another noticeable point about this bath is the combined waste and overflow fitting which couples on to the bath by means of ordinary screwed unions. Quite recently I fitted a bath costing £40 which had to have a purpose-made lead/

lead overflow pipe wiped on to the fittings provided with the bath. It appeared monstrous to me that a firm manufacturing an expensive article such as this should allow it to leave the factory in an uncompleted state, i.e. without a fixed overflow, and moreover, ^{that the bath} /should be provided with fittings that bring in the costly and out-dated wiped joint as an essential part of the installation of the bath.

There is no reason at all why lead and solder should be brought into the fitting of an overflow pipe which is simply linking up two fixed points - the actual overflow aperture in the side of the bath and the boss in the side of the trap adjacent to the bath waste. If bath manufacturers cannot standardise a built-in overflow in every case then surely it would be quite an easy matter to turn out a *prefabricated overflow pipe, say in copper, that the plumber could fit quickly by flange nuts or the like. It ought also to be possible to incorporate the trap in the bath casting, so long as a large plug for cleaning purposes is included in an accessible place.

Substantial savings in space and cost could be achieved by popularising the combined bath and washbasin in a form more asthetically acceptable than hitherto. What is needed is a form of dual purpose casting that would allow the/

* This fitting is obtainable now.

the one set of taps, waste and overflow to fill and empty either appliance. The idea of a combined appliance is sound, for it is extremely rare for the washbasin and bath to be required at the same time and the elimination of the costly duplication of pipes, fittings and taps ought to make it worthwhile for manufacturers to give it serious consideration. The two main difficulties to be overcome are first, to raise the washbasin in the casting to a suitable height, and second, to achieve a reasonable appearance. A further difficulty which is likely to arise is that of persuading the manufacturer of the dual fitment to market it at a competitive price, and not, as seems to be the case with the Scottish combined tub and sink fitments, to fix a price that fails to reflect any appreciable saving whatsoever.

On the subject of the wash tub, it is remarkable that so many Scottish/^{local} authorities have been successful for so long in enforcing the provision of an approved tub fitment in all new houses in addition to the usual kitchen sink. In these notes it is not disputed that the tub fitment is a very useful addition to the equipment of any kitchen where the housewife attends to the family wash, but it is very surprising that some forty millions of people in England/

England ~~have, and~~ are managing their household laundry work quite satisfactorily, generally without the aid of a wash tub fitment, while in Scotland, some five millions of population, spurred by some atavistic urge ^{apparently} are/washing clothes to such a degree that thousands of wash tubs and many more drying area posts together with acres of drying ground are needed to satisfy this urge.

This insistence on an additional sanitary fitment involving extra expense in pipe run, waste, trap, taps, overflow, etc., not to mention the provision of valuable living space to house the wash-tub, is questionable insofar that the requirement applies to all houses, and does not take account of the case where the householder washes a few small things and sends the rest to the laundry. There are many households where this occurs in Scotland and the tendency seems to be that the number of people who do without home laundry facilities is increasing. Yet the insistence of local authorities on this provision of a wash-tub is almost inflexible. Only recently a batchelor wrote to the Scotsman complaining that he had applied for a minor Dean of Guilds warrant to permit him to re-dispose the accommodation in his small house so that the existing kitchen on the first floor became a bathroom and the existing bathroom on the ground floor was converted into a kitchen.

The result of this quite innocent application was/

was enough to ^{persuade} ~~deter~~ anyone reading about it to resolve never to have anything to do with any alteration or conversion of property which involved asking for official sanction.

This particular petitioner was told that, among other things including the installation of new drains, partition walls of brick or block instead of existing stud partitions, vent pipes in duplicate, etc., he must install a proper wash-tub along with the existing sink!, for which, as he pointed out, he had no possible use, since his was a batchelor establishment and consequently all his soiled linen went out to the laundry. However, this line of argument failed to move the Dean of Guilds and ultimately the poor man installed a washing machine, since this particular local authority had a saving clause providing for such a machine in lieu of a wash-tub. (Though, as the man pointed out, there was nothing laid down in the local authority's by-laws stipulating what he had to do when the washing machine became worn out!)

This description of what is possibly an extreme case of hardship arising from this rigid insistence on a wash-tub in addition to a sink has perhaps taken up a little space, but it does serve to show that some economy could be secured in certain classes of houses, mainly those that are now being erected for sale to private purchasers, by making the provision of the wash-tub optional, according to the particular purchaser's preference.

HEATING INSTALLATIONS AND THERMAL INSULATION.

The provision of heating services in modern house-building is not always related to the constructional aspect and it is not easy to confine these notes to heating installations only so far as they are linked with a new constructional technique in house-building. At the same time however, a consideration of thermal insulation is inescapably linked to any study of heating services as it also is to any examination of the fabric of a building.

The reduction of heat loss, and the consequent economy in the cost of heating installations and fuel is, of course the main raison d'être of thermal insulation and it is perhaps not generally realised that the careful design of a well insulated house may mean a saving of £3 to £4 in the annual fuel bill, and at 3% this could be said to represent a capital sum invested of some £100 or so. But if £100 or more has to be spent on the thermal insulation of the building then the saving will be cancelled out - so it is evident that the degree of insulation to be provided in the fabric of a building may well prove to be an economic problem.

It can be shown that heat transmittance may be substantially reduced when a first layer of insulating material/

material is inserted in a wall, but this reduction of heat transmission does not continue in the same ratio to the thickness of insulating material that may subsequently be added to the initial layer. Therefore the problem is to fix on the amount of insulation to be used, having regard to this diminishing advantage of heat resistance and to the importance of keeping the overall cost of the insulation well below the level of the anticipated saving in plant and fuel cost.

When the Building Research Station completed the well known experiments on the six houses at Garston ⁽ⁱⁱⁱ⁾ it was shown that the saving in fuel from efficient thermal insulation made it worth while to ^{incur} ~~spend~~ £60 additional cost on the erection of a small house. This expenditure made for a saving of about 15 cwt. of anthracite per year, which, at that time worked out at about £4 annually and at 3% this would represent a capital sum invested of £133 - quite a lot more than £60.

Perhaps the first constructional techniques used in Scottish house-building, resulting in improved thermal insulation, were the strapping of external walls and the "deafening" of tenement floors. In ~~neither~~ of these cases had the earlier builders any notion or intention towards thermal insulation, but the improvement in insulation was achieved nevertheless. In this modern age of conscious planning for thermal/

thermal insulation the methods adopted fall generally into three categories:- (i) the introduction of air spaces in the floor, wall or roof, (ii) the insertion in the wall, floor or roof thickness a layer of insulating material such as cork or glass-wool, and (iii) the use of lightweight cellular materials such as Vermiculite concrete or clinker or pumice aggregate blocks instead of the conventional dense concrete or brick.

In the first category the example of the "strapped" external wall has already been instanced and another common example is the cavity brick wall. Then there is the less commonly adopted but highly efficient technique of double glazing, where double windows with a minimum spacing of $\frac{1}{2}$ in. will halve the heat loss through a single window. The cost of double glazing is excessively high in this country and very discouraging to the enlightened client or architect who seeks these very tangible benefits of double glazing. The methods mentioned under (ii) and (iii) have been the subject of a number of references under Walling, earlier in these notes, but little has been said about the insulation against heat loss in the roof. The roof is probably the most vulnerable part of the house so far as heat loss is concerned, usually there is the vast reservoir of cold air in/
in/

in the roof space - replenished from time to time by the free entrance of cold air from outside. The normal Scottish provision of butt-jointed boarded sarking helps a little to insulate the roof but tongued and grooved boarding would be far more effective. In some of the more recently built housing estates around Edinburgh I have seen roofs provided with a sarking of $\frac{1}{2}$ in. thick insulating board, laid directly on to the rafters in 8 ft. by 4 ft. sheets. Tile lath are nailed through to the rafters and concrete interlocking tiles are then fixed to the tile lath. This construction should provide quite a good standard of insulation because the insulating boards form an almost continuous covering over the entire roof, the 8 ft. edges being butt-jointed over the rafters and leaving only the 4 ft. edges as a potential air leakage point. The addition of a covering of roofing felt or building paper over the insulating board would effectively seal off these leakage points and raise still further the standard of insulation, though counter-lathing is essential.

This form of roof insulation is unsuitable for slated roofs because it is not possible to nail slates effectively to the insulation board which is necessarily open in texture and does not readily provide a secure grip for the nails. What can be done, of course, is to fix lath to/

to the insulating board as for tiling, the slates then being nailed to the lath.

In addition to the actual roof covering the ceiling immediately below the roof should be provided with an insulating layer of some kind. Materials such as slag wool, glass wool, vermiculite granules, cork, etc. are available as "loose fills" for topping up the space between ceiling joists ; then there are many forms of quilted materials such as glass wool that may be draped over the whole of the upper surface of the ceiling in a continuous layer.

By providing this insulation the rate of heat loss through the conventional pitched roof may be reduced considerably - sometimes as much as 50% by the provision of the ceiling insulation alone. With the price of light-weight glass wool quilting at about 4/- a square yard it is possible to cover the average two-storey house ceiling for £10 or so.

From what has been said about the advantages of insulating the fabric of buildings it is quite evident that there are distinct benefits to be gained from new constructional techniques which take full account of the potential heat loss through the building fabric.

Considerable interest has been shown during the past five years in electrical floor warming ⁽¹¹²⁾ where electrical elements take the place of hot water piping. The elements are incorporated in the floor during construction, either in semi-circular ducts or solidly embedded in the floor material itself, the material usually being concrete made from refractory aggregates.

Installation costs are very much lower than those for conventional systems involving piping boilers, chimneys, etc. All that is needed is the heating element together with the electric supply.

The chief advantage of the new floor heating system is the ability of the floor material to contain and store the heat generated from electricity used during "off-peak" periods (usually during night-time) and then to shed the stored heat during the daytime when the building is fully in use. Some adjustment of the periods for the intake and output of heat is necessary according to the type of building to be heated. For example, a school used only during the daytime can draw on the electricity supply for seven hours or so from 1.0. a.m. to 8.0 a.m. and may then be switched off and allowed to emit heat from the classroom floors for the rest of the day. It has been found that no appreciable drop takes place in the temperature during the five hours following the time at which the electricity is switched/

switched off. Later on in the day it is possible to turn on the current for a few hours if required.

Schools are said to be particularly suited to this form of heating because they are rarely occupied during late evening and it is usual for the overnight warming up to be sufficient for the 9.0 a.m. to 4.30. p.m. period of use. Electrical floor warming has been adopted in the recently erected "all-electric) flats at Kirkaldy. Here the eight-storey building has floor warming in the hall and living room in each flat with electric fires in the other rooms.

In the Kirkaldy flats the floor heating to each flat is loaded to about three kilowatts and the cost of installing the rewirable type of floor heating together with all the associated electrical work worked out at about £25 per kilowatt. At a total cost of £75 the installation compares well against the cost of, say a tiled fireplace surround plus the additional material and labour taken up in building the chimney breasts, chimneys, foundations, etc.

If a reasonable "off-peak" rate of payment is fixed, say at $\frac{3}{4}$ d per unit then the floor heating to each flat should run at a little over 2d. an hour during the night-time. If one reckons on eight hours running then this should work out at about 10/- a week, which is much less/

less than the cost of supplying the average open fire with solid fuel during a week's running. And this calculation does not take into consideration the floor warming in the hall of each flat.

Heating installation design is often bound up with the consideration of condensation, for it is quite easy to design a heating system providing for a building that is unoccupied throughout the daytime, by injecting heat rapidly into living rooms by one means or another. Yet at the same time the temperature rise may be accompanied by a humidity rise that causes the inevitable condensation on cold walls. New impervious types of walling, cooking on flue-less stoves, solid concrete ground floors, all encourage condensation in many troublesome forms such as streaming wet walling, misted and vapour-streaked windows and inundated window sills. The incidence of condensation may be more serious in multi-storey flats where impervious curtain-wall surfaces have caused moisture to be deposited and trapped within the wall fabric, though usually it is not so serious as that but is plainly annoying to the people who have to live with it.

Since condensation is brought about by the contact of air-contained moisture with a cold surface it follows that the cure can be effected by removing one of these two factors./

factors. Either the humidity of the air must be reduced or something done to replace the cold surfaces by some form of insulating material or other surface application. The humidity can be reduced by the avoidance of indiscriminate steam distribution from kitchens and bathrooms, and by the avoidance of sudden changes in temperature within the building. Electric floor heating should do much to reduce humidity owing to its characteristically slow-moving changes in temperature.

Condensation within flues has demanded a new method of construction to counteract it, for it has caused a very considerable amount of trouble and expense within the last few years. The trouble has been caused by the slow-combustion types of stoves which discharge moisture-laden flue gases into the orthodox chimneys. The flues are so much cooler where these slow-burning appliances are used and condensation occurs on the cooler parts of the inner surface of the flue; this moisture often dissolves deliquescent salts from the waste products in the flue gases and these salts may produce disfiguring staining or may attack the joints in the brickwork surrounding the flue and cause the stack to lean and possibly collapse. The precaution to be taken against this is to line the flue with glazed ware pipes or similar material that is likely to resist the attack of these sulphurous products.

In this critical examination of new constructional techniques it is possible to examine only those methods of heating installations that demand a new technique of building in one way or another, and although there are very many different forms of heating systems used in house-building the only systems that can be said to fall into this category are the floor heating systems and the forms of heating which reduce or remove the usual provision for hearths, chimneys, fireplaces and flues.

The effect of free-standing slow combustion stoves on conventional forms of fireplace openings and chimney breasts has already been discussed in the section devoted to Walls (Fireplace Openings and Flues), and it has been said that these appliances can operate efficiently, more efficiently in fact, if the usual massive chimney breasts and fireplace openings are dispensed with and only a simple flue connection provided in the wall.

It would be difficult to economise further than this with any local form of heating using solid fuels. There are left the two alternative forms of heating - (i) central heating by solid fuel, oil or gas, in which the number of fireplaces and chimneys are substantially reduced (district heating as used at Bonnyrigg may remove the necessity for chimneys altogether)/

altogether) and (ii) central or local heating by electricity.

The house which is centrally heated should be cheaper to construct than one which is not. The reduction or omission of ~~the~~ breast walls and stacks represents a distinct saving in cost and there may be an improved opportunity for light prefabricated walling instead. Moreover, there is the additional advantage of whole house warming in that there is greater freedom of planning with consequent economies from the elimination of partition walling, doors, etc. Apart from the savings resulting from the reduction of brickwork in chimneys, etc., there is a saving in plumber work involved in making the chimney stack weather-tight where it passes through the roof, not to mention the cost of maintenance which is always a factor to reckon with.

District heating, where the water for heating and domestic purposes is centrally heated in a communal boiler house, undoubtedly achieves the economies in construction which have already been described. Whether this system of heating a group of houses or flats is itself economic is hardly within the scope of these notes, certainly the experience of the local authority responsible for the Bonnyrigg scheme has been that the system works more often at a loss rather than a profit.

Local/

Local forms of heating by electricity have been available for a long time. Usually the method adopted has been direct radiation from electric fires - mostly in bedrooms. During the past five years there have been many new developments in electric heating appliances, electric convectors, electro-vapour radiators, tubular heaters, unit heaters and electric oil-filled radiators - more recently there has been the electric "storage" heater consisting of elements embedded in large blocks of solid refractory material. The elements are controlled by a time switch that limits the input of electricity to "off-peak" periods when electricity is more likely to be supplied at a cheaper rate. Thus the current flows through the elements for eight or nine hours during the night, and during this time about one-third of the heat generated is given out immediately, the remainder being stored in the refractory material and given out during the following 15 or 16 hours.

The cost of electric current and the almost prohibitive cost of electrical heating appliances tends to put this form of heating into the luxury class and consequently outside the range of ordinary house heating. This is unfortunate because there is so much to be said in favour of heating by electricity. There are all the economic advantages already mentioned, with regard to savings in brickwork in chimneys, etc., and there are other advantages of flexibility of control, cleanliness and appearance.

ELECTRICAL SERVICES.

Probably the most important advance in wiring practice in post-war house-building has been the development of the new standard 13 amp. socket and plug incorporated in the ring circuit. This development followed the recommendations of the Committee convened by the Institution of Electrical Engineers and responsible for the publication in 1944 of Post-War Building Study No 11 on Electrical Installations. These recommendations were for the standardisation of a single type of plug and socket to be used universally in place of the many differing sizes of plugs and sockets used in buildings at that time, for the use of a new and more economical type of circuit for wiring the new standard socket-outlets and for the official acceptance of cable coverings of plastic material instead of the normal rubber insulation.

The need for a single size of plug and socket in modern buildings has been apparent to almost everyone for a long time. A single room in a house may contain three sizes of plug and socket, 15, 5 or 2 amperes. And the occupant of that room may, if he wishes or does not know any better, connect a table lamp to the 15 amp. point, an electric cooker to the 5 amp. point and perhaps an electric fire to the 2 amp. lighting socket. In the first instance the loading/

loading imposed by a table lamp on a separate 15 amp. circuit is very substantially below the capacity of the 15 amp. fuse, and the consequence of this is that in the event of a fault developing in the circuit the lamp would be more likely to fuse before the fuse in the fusebox. This "pre-fusing" could apply similarly if say an expensive piece of apparatus such as a television set was connected to a 15 amp. socket.

In the other two instances the effect is simply of overloading. If the circuit is correctly fused then all is well because the extra load of a kilowatt fire on a 2 amp. circuit should blow the fuse quickly before further harm results and the effect of connecting a cooker to a 5 amp. socket should be equally speedy. But oldfashioned fusebox arrangements are wide open to abuse by amateurs and it is by no means unknown to find a 5 amp. fuse that has been renewed at some time or other and supplemented with six or even a dozen strands of 5 amp. fuse wire. This form of abuse puts the entire load of the appliance on wiring that may only be capable of withstanding safely a few 5 amp. appliances. A fusing in a weak inaccessible place may lead to a fire with disastrous consequences.

The Institution of Electrical Engineer's
(114)
Regulations specify the number of sockets that can be connected/

connected on any one circuit, for example a 15 amp. power plug and socket must be provided with a separate circuit. This, in a modern house where electric fire and similar appliances may be used in all living rooms and bedrooms, means that a great deal of expensive 7/.029 cable is needed in the multiplicity of circuits.

The ring main principle has for a long time been applied to electrical distribution and now it has been used in interior wiring with the new 13 amp. socket-outlets connected to it. The diagrams ^{in most textbooks} ~~on the next page~~ explain how simple the ring main principle is compared with the circuit arrangements for four 15 amp. old-type socket-outlets. In the ring main circuit the 13 amp. socket-outlets have independently fused plugs and the fuses are adjusted to suit the appliance which is connected to the plug. This independent fusing eliminates the need for a distribution board with the usual fuseboxes mounted on it and it is quite clear from the diagrams that there is a substantial saving in cable used in the ring main circuit.

For the electrical arrangements in a small house the Regulations of the Institution of Electrical Engineers ⁽¹¹⁴⁾ allow an indefinite number of 13 amp. socket-outlets/

outlets to be connected to each ring main. Thus there may be upwards of four socket-outlets in any living room or bedroom, every appliance will plug simply into every socket and if more socket-outlets are required after the initial wiring is completed then the cost of inserting the new points is much less than it would be for additions to the older form of circuit where it is possible that a completely new circuit would be required.

The considerable saving in cost achieved by the adoption of the ring circuit is a fact that should be quickly grasped by the architect and others responsible for electrical installation in house-building, though it is not evident so far that these potential savings are generally appreciated and accepted.

Switches, sockets, plugs, lamp-holders and many other electrical fittings manufactured in plastic material have for some time been accepted and widely used in the electric equipment of buildings. Polyvinyl chloride compounds have more lately been developed in the manufacture of conduits combined with the production of plastic insulated cable, and it is probably true to say that the future will see much more of this material used in the wiring of buildings than hitherto.

For many years, the experts in electrical installation/

installation work have declared steel conduit to be the only really satisfactory protection for the normal vulcanised rubber-sheathed cable and even were plastic insulated cable to become universally adopted there is little doubt that most of the electrical contractors will advise that this type of cable be run inside steel conduit.

But steel conduit is prone to rusting or corrosion and there is always the risk of the electrical continuity of the conduit being broken by destruction of the conduit through plaster corrosion or rusting set up by condensation. Moreover, P.V.C. conduit can be produced in a flexible form that lends itself to many situations in building work where, with steel conduit, it would be necessary to introduce bent fittings or other special and expensive means of getting round an immovable object.

The early, and sometimes unsatisfactory forms of plastic equipment that first found their way on to the market have inevitably prejudiced the contractor against this new material and it is exceedingly difficult, without exercising the utmost firmness, to persuade him to use anything but the customary rubber-sheathed cable protected by steel conduit. Anyone who has watched the average electrician at work installing the orthodox wiring in a building cannot but have been exasperated by the downright/

downright waste of time that takes place when cast iron switch boxes, junction boxes and similar pieces of equipment, all in cast iron, are being drilled for fixing to the wall, ceiling or other place. Usually, powered hand drills are not available and something like ten minutes is used up on drilling each box by hand. One is left wondering why good type plastic boxes, easily drilled or adapted to any situation, have not been insisted upon by those whose job it is to watch the everlasting drain on the client's pocket.

Contractors also appear to display the same degree of reluctance to adopt the new "plaster depth" boxes for switches and socket-outlets and thus do away with another time-wasting business of cutting out for the normal deep box with its old type switch as against the newer type slow-break micro-gap switch which can be accommodated in a shallower box.

Apart from the developments in the production of plastic conduit there have been one or two interesting forms of inverted trunking or conduiting placed on the market. The method adopted by one firm is to fix a light trunking of extruded aluminium section with a spring steel cover to beams or to ceilings, or to cast it in situ or recess it in plaster work. The trunking accommodates the circuit with ample room to spare and fittings are easily connected to the trunking.

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The ring main circuit has made for considerable simplification of the control unit between meter and house circuit and the British Standard 1454 has helped to achieve a measure of standardisation. Some makers still supply the old-type fuse bridges that can be repaired by the householder but in general the electrical contractors are favouring the control unit which houses the cartridge-type fuse. These fuses effectively ensure against the possibility of the consumer inserting the incorrect fuse, for it is practically impossible to put any but the right size - 5 amp., 15 amp. etc. - into the particular cartridge shaped housing which is recessed to receive the correct fuse.

The new method of fusing certainly helps to minimise the risk of fire through uprated fuses but the new fuses are far more expensive than they ought to be. They cost from 5d. to 8d. each, at least three times more than they should be, quite recently I paid over eight shillings for six 18 amp. and six 5 amp. cartridge fuses. This overcharging by the electrical industry is bound to cause some amateur experimenting to avoid purchasing the correct fuse and the result of this experiment may well be as bad as the amateur replacement of the old bridge-type fuses.

Small/

Small easily-reset mechanical circuit breakers used in place of fuses have been on the market for some time now and have been used to a small extent on public buildings where the delay usually associated with the repair of a fuse might have serious consequences. Something of this kind might well be adapted to house wiring; I have always thought that it should be quite easy to design a rotating fuse-holder containing two fuses, the principle being that when one of the two fuses has blown, a simple turn of the rotary holder through 180 degrees would bring the second fuse into line and restore the current almost at once.

Very little seems to have been done in the prefabrication of wiring systems in ordinary housing work. The little that has been accomplished has usually taken the form of a centrally placed junction box in the roof space with pre-cut cables radiating out to pre-determined points. The switch and socket outlet boxes have still to be recessed into walls, and, short of the shallow fittings already mentioned, the hammer and chisel work involved in these operations is deplorably costly.

If a contractor, in wiring an existing building, brings his cable down behind a door facing or architrave, and positions the switch in the centre of the facing or architrave, /

architrave, it is considered by the trade to be a "cheapjack" method of wiring - mainly because the switch is not placed clear of the door surround. Yet it is surely quite a reasonable proposition for a switch to be situated in the door facing; the switch is readily discovered and groping fingers over a painted wood surface are less likely to leave stains than if there is a clear stretch of light papered wall surface between the door surround and switch.

From what has been said about new wiring methods, materials and appliances it would appear that there is every prospect of more efficient and less costly electrical installations in future house-building. It is obvious that the most careful consideration must be given to any relaxation of standards in the electrical equipment of any building where one is dealing with wires and fittings that under certain conditions involving carelessness or ignorance can kill man or child and can still further endanger the life of would-be rescuers. But the new methods that have been described - the ring main, the new socket-outlets, the plastic conduit and plastic insulation to cable - they are all cost-saving techniques of electrical installation that seek, in addition to economic considerations, to improve^{insulation} and safeguard the occupants of all buildings against injury or loss of life from faulty circuits and fittings.

SITE USE OF POWERED HAND TOOLS.

It is quite common now to see powered hand tools such as drills, saws, sanders, etc., being used in workshops where building components are made. But it is comparatively rare to see powered tools in use on the building site. It is quite obvious of course that a widespread building site is a different proposition to the compact workshop with conveniently placed power points connecting to a mains supply, but this aspect has been fully considered by the manufacturers of powered tools, and portable generators are obtainable that are easy to operate and are quite reliable in action.

The site operation of powered hand tools must be well organised if it is to be successful. There must be a sound maintenance system to reduce the time-wasting and exasperating instances of minor breakdowns and the further waste of time and poor workmanship occasioned by dull cutting edges. Also good operating technique must be assured by well trained operators, and overall planning and supervision is essential to ensure that the right tool is available at the right time and in the right place.

Given these things there is no reason why the employment of powered hand tools on the building site should not/

not make a tremendous difference to the output of joiners, plumbers and electricians.

The tools which are most adaptable to site work extend over a wide range and include appliances that will perform most woodworking operations such as saws, planers, housers and mortisers. Most of the saws may be adapted to cutting material other than wood; special abrasive discs are available to cut slate, clay products, asbestos cement, etc. These tools are usually electrically driven and are fitted with motors to suit A.C. or D.C. so that they may be connected to mains supply or to a portable generating plant.

Portable drills are exceptionally useful on building sites and are used by most of the building trades. They can be obtained to take drills varying in size from 1/16 in. dia. to 1 in. diameter and the insertion of mandrels can increase the size of hole that can be drilled up to 4 in. diameter. These drills may be used with special bits to serve as screwdrivers or powered box-spanners for tightening or unscrewing nuts.

Hammers and vibrators are possibly the best used site power tools, though pneumatic hammer drills are most usually associated with holes in the road rather than on buildings. But there are a great many uses for the powered hammer in the normal run of building work - anyone familiar with/

with the all too frequent un-mechanised conditions on the building site will be familiar with the slow rhythm of the hammer applied to the plugging (dooking) chisel, or to the cold steel chisel in cutting chases, holes, etc. The powered hammer can be used for these operations and it is claimed that it can give a rate of work from ten to thirty times faster than normal hand methods, according to the particular type of work. The powered hammer may be actuated by a unit run from compressed air, petrol or electricity; it can be obtained in several different sizes and all kinds of "bits" or tool inserts can be fitted to the hammer ranging from a raking-out tool for brickwork joints to surface vibrators and vibrating trowels.

Cutting work done by a powered hammer is usually more accurately done than by normal hand methods and it is claimed that the electrically powered hammers can be run at less than a halfpenny per hour of actual hammering. Where electricity is not available and the hammer is powered by air it is now possible to obtain a small portable diesel-driven air compressor that is capable of unloading a working pressure of 80 lb/sq.in. The compressor may be moved around the site on its two pneumatic-tyred wheels by one man in much the same way as a wheelbarrow. The cost of this item of/

of equipment is approximately £250 without the various tool adaptions.

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The "gun" type of power-driving tool was introduced into the building industry well over six years ago, but there is little sign, in Scotland at any rate, of its general adoption by contractors. These guns actually fire fixing pins, rivets, etc. into brickwork, masonry, concrete, wood and can even drive hardened pins into structural steel. A cartridge of approximately .22 bore is detonated by the firing mechanism and generates a tremendous force of expanding gases which drive the power pin through the barrel at an extremely high velocity. This enables the power-driven pin to penetrate deeply into very hard materials in which the particles are displaced by the passage of the pin and then they stress back as far as they can towards their original position, and in so doing they exert a powerful clinching action on the embedded pin, so that it remains firm and immovable against any load which is placed upon it.

These power-driving guns were used on the Scottish tional Library building to fix a great number of timber straps to the brick filler walls, and there seems to be little doubt that the cost of the gun together with the few pence for cartridges and fixing pins has been more than saved by the reduction of manhours that would otherwise have been employed in cutting out for and fixing "dooks".

A recent invention has produced a "take-off unit" that converts any car or van into an independent power source for driving many labour-saving site appliances such as circular saws, pumps, mixers, etc., and certain types of hand tools. This unit consists of a welded steel frame fitted with a fixed driver pulley and an adjustable idler pulley. These pulleys are distanced so far apart that the rear wheel of the car or van can be jacked up and then dropped between the two pulleys. Then when the car engine is started up and low gear engaged a belt transmits power from the driver pulley to the saw or other appliance. This idea is obviously limited in application to small sites where no other power source is available but it should certainly be worth any builder's while to invest a few pounds in this simple piece of equipment which has so few working parts to go wrong.

All too few contractors make early arrangements for power supplies on the site; many wait until a few houses are completed and the public electricity supply is made available. Any builder who has his own tractor can buy a generator for upwards of £20 which he can run from his tractor and thus obtain on-site electrical power at negligible cost for running power-hammers, drills, saws, mixers, and all the many other powered hand tools that make for savings in scarce manpower.

The use of the power float for finishing concrete floors is undoubtedly effecting substantial economies in modern floor construction. The machine itself consists of a circular disc, a power unit and a cranked handle for steering it. The disc is in contact with the floor and rotates at a considerable speed; the weight of the machine is about 2 cwt. and when not in use it can be moved around by attaching two wheels and a lifting bar.

The function of the power float is to level ordinary site concrete down to a smooth, hard, true surface. In effect it is employed to do what the floor screed has always attempted to do, to provide a level sub-floor for the floor-layer to fix his blocks, tiles and other finishes to. . . In removing the necessity for the cement screed there are a number of advantages; first and most important - a trade process is cut right out and money saved through it, at the same time the risk of the failure of the proper adhesion between screed and subfloor is removed. In addition to these advantages the period of waiting for the floor to dry out is reduced, for quite clearly the sub-floor will be laid at the commencement of the job and should be dry by the time the floorlayer arrives on the site.

A final point in favour of the power floated floor/

floor is that the finish from the float is consistently good. With a 24 inch diameter float the imperfections of the hand laid screed are largely avoided; the float can produce a smooth close textured surface suitable for the effective adhesion of thin thermoplastic tiles, or a coarse finish can be obtained where a deeper bonding action is desired, as, for example, where hardwood blocks are to be laid.

It is claimed that the superior compaction of the power float makes it possible to employ leaner concrete mixes than with hand-compacted site concrete. Most certainly there will be a saving in materials through dispensing with the screed. The running costs for the power float are generally around 3d. per yard super., including fuel, maintenance and the operator's wages, and as with most machines, sufficient work is essential so that the power float is never idle.

Probably the only point of criticism arising from consideration of this power float technique is that the normal concrete floor, after floating, is subjected to a great deal of traffic in the course of building the superstructure. Heavy weights are dropped on it and much mortar and debris are scattered over it, so that by the time the floorlayer is ready to commence work, it may be necessary to patch up the floor or even to screed it after all. Experience has shown so far that this does not occur very frequently, because the power float leaves a hard, traffic-resistant surface on the concrete.